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Learning in Dementia Precox

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A STUDY FROM THE PSYCHOLOGICAL LABORATORY OF THE GOVERNMENT HOSPITAL FOR THE INSANE, WASHINGTON, D. C.

With an Introduction by
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INTRODUCTION

Investigations of the factors influencing or effecting the training of the insane are intimately associated with the psychiatric problem of the occupation of patients. This problem is a practical one of great importance to hospitals for the insane, for upon its satisfactory solution depend many therapeutic procedures and financial readjustments. As long ago as 1830 occupation as a means of treatment of the insane received recognition in this country.[1] Although strictly controlled observations were lacking it was believed, for example, that an excited patient should be given employment, that his diffuse, and often destructive, movements would be replaced by those of practical value, and that, thereby, the random and apparently purposeless activity (and, *pari passu,* the mental abnormality) would give place to more normal conditions. It was also believed that the occupation of a melancholic patient would cause him to pay attention to the movements of his occupation, and that, in this way, the attention might be directed away from his fancied wrong-doings and his ills. In cases of primary dementia, so-called, employment was believed to be an effective method of retarding, if not of aborting or curing, the dementia. Coupled with these thera-

[1] The introduction of occupation as a therapeutic measure with the insane antedates this period by some years. Combe in 1831 refers to occupation as having been used in various institutions much earlier than this period. (See A. Combe: Observations on mental derangement. Edinburgh, 1831. Page 364.) An excellent account of an early view of the occupation of the insane is to be found in Prichard. (J. C. Prichard: A treatise on insanity and other disorders affecting the mind. Philadelphia, 1837.) In a footnote in that work (page 215) the conditions in the Richmond Lunatic Asylum, Dublin, Ireland, are cited, "where out of 277 patients, 130 are actively and usefully employed, *viz.,* 18 in garden labour, 16 in spinning, 12 in knitting, 18 at needle work, 12 in washing, 16 in carry coals, whitewashing the wards, tailoring and weaving, and 12 in learning to read." The last mentioned occupation, and others similar to it, might well be introduced or re-introduced into the hospitals for the insane, for upon the capability of the patient depends much of the success of the so-called after-care.

peutic beliefs the financial aspect of employment became prominent. In institutions for the insane there are multiple tasks of different characters which must be performed, and for which the institution must hire or supply workers. If some of these kinds of work can be satisfactorily performed by patients, there becomes available the money saved by reducing the amount for paid service, which can then be utilized for the purchase of more or better food and other comforts, in amusements and in a variety of other ways for the benefit of the patients. A decrease in absolutely necessary operating expenses may also be utilized to the advantage of the community by a reduction in the cost of maintenance. In many institutions at the present time this financial aspect of patient employment is apparently believed to be the more important. When, however, the insane are considerd, as they should be, individuals who are ill and whose conditions require medical attention, it is the *therapeutic* aspect of occupation that should be predominant. It is not necessary that the therapeutic and financial aspects be separated entirely, for it is not only believable, but also probable, that the useful occupations, as therapeutic measures, are as beneficial as the so-called artistic occupations.

Although the belief is rather general that occupation is a therapeutic measure of value, recorded observations of the effects of different kinds of work on different classes of the insane are wanting. There are many articles and reports containing expressions of belief, and others of the nature of general discussion, and it is evident that in the selection of occupations and patients for the work much attention has been paid to local needs and individual preferences. A careful examination of psychiatric literature shows that in its scientific aspect the problem has scarcely been touched upon. Although the recording of casual observations in a matter of this kind is of value, this cannot take the place of experiment or of controlled observation. In this matter the rule of thumb should not be permitted to usurp the place of more accurate measuring instruments, for the problems from the standpoint of the hospital are therapeutic ones.

From what has been said it will be appreciated that the occupation of the insane must be considered from several angles if we

are to have adequate information for practical guidance. The more important of the angles from which to view the matter are the therapeutic or prescription angle, and the economic or financial angle. If the matter be looked at from one angle without considering others, there must result a loss to the patients because of this one-sided view, and it is only by a proper adjustment of observations from all angles that a correct and equitable solution of the complex problem or problems will be reached, and the patients thereby receive the greatest benefit.

The psychiatrist who has charge of a ward containing 100 patients, or of a hospital containing several thousand patients has a number of questions to ask: "Is occupation a measure for the relief or retardation of certain mental diseases?" "Is it beneficial in all mental diseases?" "If not, in what diseases is it beneficial?" "To what extent should this therapeutic measure be used, and in what stages of the diseases is it indicated or contraindicated?" "Is it harmful to certain patients, irrespective of the type of the mental disease?" These questions, and many others, can not be answered definitely at the present time. They will demand for solution the attention of many workers, using the best scientific methods, before definite answers can be given and before reasonable prescriptions of occupation can be formulated.

The local financial and the broader economic aspects demand attention in a thorough consideration of the subject, but the latter have little bearing upon the welfare of the patients and will not be dealt with here. The narrower financial aspect must be taken into account. Officers in hospitals for the insane must consider the cuts, and the prices and the methods of cooking of beef for bodily welfare and for taste, and in therapy there are similar limitations of expenditures for medicine and medical attendance. The kinds of occupation, the costs of materials and the salaries of teachers or supervisors are important items to be considered if it be definitely established that this method of treatment is to be used in a proper manner and not like the cure-all blood-letting of former days. Assuming the general therapeutic value of occupation to be established, there are a number of questions to be answered: "What kind of occupation is best

fitted to restore certain types of patients to mental health?" "Are the common tasks of the home, of the farm, or of the factory useful means of bringing about cures?" "Or, are those occupations of a nature less familiar to the patient the more beneficial to him?" It will be appreciated that answers to these questions, although of therapeutic importance, have great financial interest. Institutions with considerable endowment need hesitate little, if at all, regarding this aspect of the question, but most state and private institutions must consider it seriously. Whether the patients are best (therapeutically) employed as factory or farm hands, or given a smattering of an art education, or amused, are, however, matters to be determined by scientific investigations. Scientific investigation must also solve the problems of therapeutic potency of various types of occupations.

The results of such investigations will have not only therapeutic and financial interest, but also a purely scientific value. It is to be expected that these inquiries will, for example, help us to appreciate better what dementia is, the similarities of and the differences between the sane and insane, and many other matters in which the psychologist, as well as the psychiatrist, has an interest. On the other hand, the investigation of the course of training, of the possibility of the insane of acquiring habits of a very complex nature, of the curve of forgetting, etc., is directly applicable to the broader problem of occupation. It was largely because of the psychiatric importance of the general problem and the relation to it of the psychological investigation of training that the present work and that of Kent, both from this laboratory, were suggested and undertaken. How far the accumulated facts may be applied to the solution of the psychiatric problem it is too early to predict. At present it is sufficient that the ground has been broken and that by the application of psychological methods there have been accumulated facts which must be considered in a thorough investigation of the important practical problems of occupation therapeutics.

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October 15, 1912.

LEARNING IN DEMENTIA PRECOX

STATEMENT OF PROBLEM

The present study considers the formation under experimental conditions of certain habits in cases of dementia precox. It aims to investigate the acquisition of motor skill in both simple and complex operations. The writer has regarded his task throughout as a problem in psychology and has endeavored to maintain a consistently psychological point of view. He hopes, however, that a psychological study of material which is more often the subject of psychiatrical investigation may prove of interest to both psychologist and psychiatrist,—to the former, because it is a direct contribution to his especial field of knowledge; to the latter, because the psychological facts may well carry a psychiatrical implication.

The scientific study of the course of training of the insane has received very little attention. The reports of hospitals for the insane often contain brief accounts of industrial work in which the patients are employed, but the details are too meager to indicate the extent of the work or the classes of patients employed. If accurate accounts of the characters and amounts of work performed have been kept, these have not been made available in scientific publications. With the exception of the study by Kent on *Habit Formation in Dementia Praecox*[1] the writer is aware of no investigation of this problem. His present purpose is to supplement the conclusions of Kent in three respects.

In the first place, the subjects were given a large number of preliminary and supplementary tests, in order that the individual mental characteristics of each subject should be more accurately known. The writer hoped that it might be possible to factor ability in some of these tests into terms of ability in other similar

[1] *Psych. Rev., 18,* 1911, pp. 375 ff.

tests. That the results of this attempt were largely negative does not, he thinks, make them unworthy of record.

In the second place, a systematic effort was made throughout all the tests of learning to train the subjects to give introspective reports of consciousness during the course of learning. Probably there is no psychologist who does not admit that the fullest account of learning must include, in addition to a record of the performance of the subject, an account of the temporal series of conscious events that occur with that performance. At least half the problem is overlooked when introspections are not required; and, moreover, the interpretations of the behavior of the subject may be wrong. Attention is called elsewhere (pp. 48f.) to a radical difference in the interpretation of data by the writer and the interpretation of similar data by Kent, the difference being due entirely to the availability of additional information furnished by the introspections.[1]

The cause of introspection in work with the insane has already been championed by Ley and Menzerath,[2] who as a matter of fact, however, obtained from their patients not so much actual introspections of conscious experiences as information and statements of meanings. Franz speaks of the introspective ability of some insane and compares them not unfavorably with normal subjects[3] of similar education or experience; but so far as the

[1] It is realized that the reliability of the introspections of persons who are insane may be questioned. For this reason, when space has permitted, there have been printed the introspections upon which the conclusions are based, making it possible for the reader to determine for himself what value he will place upon the reports. The whole question of reliability is too large a one to enter into this article. The writer has, however, recently obtained introspections under the same conditions from uneducated normal observers and from trained introspectors, and has determined by a comparison of these introspections with those of the insane subjects, not only the reliability of the latter, but also the extent to which certain self-made expressions of the subjects may safely be translated into technical psychological terms. See *Introspection in Dementia Precox, Am. Jour. Psychol., 24,* 1913, pp. 145 ff.

[2] *L'etude expérimentale de l'association des idées dans les maladies mentales,* 1911, p. 32.

[3] *Psychological Opportunity in Psychiatry, Jour. Philos., Psych. and Sci. Methods, 3,* 1906, p. 567.

writer is aware no serious attempt has been made to train insane subjects to introspect.

In the third place, the present work was concluded by the study of the learning of a practical industrial operation. It is not always desirable to conclude that the ability to learn in certain standard laboratory experiments necessarily indicates ability to learn a fairly complex operation, such as is met with in everyday experience. For this reason the work of the tests was followed by the learning of an industrial problem, in which the performance of the subjects was measured and quantified, as far as possible, in the same way as in other experiments in learning.

Throughout the work an especial effort was made to avoid the use of complicated apparatus, which may easily disturb insane subjects and interfere with the results. One patient used in these tests (see page 13) would, for example, have resolutely refused to have anything to do with contrivances of an electrical nature, for he would have believed that "electrical influences" would do him great harm. It was in order to avoid the distraction that is so likely to occur with dementia precox patients, that, in two of the tests, the subjects, instead of being blindfolded, were prevented from seeing the work by a small curtain. In all cases the effort was made to restrict the materials employed to the most familiar articles,—paper, pencil, and cardboard. The most complicated piece used was the metronome, which was left in sight for many days before the experiment began and was casually explained to the patient and handled by him at times before it was put into use.

CASE HISTORIES

The experimental work was performed at the Government Hospital for the Insane, Washington, D. C., in the summer of 1912. Eight subjects were used. These were cases of dementia precox, in some of which the disorders of conduct that gave rise to the diagnoses were of comparatively short duration. There follow the records of these patients, in which will be found general accounts of their histories previous to admission, taken from the records of the hospital, and more detailed ac-

counts of their histories since admission to the hospital, especially during the period of experimentation.

Subject A: (Case No. 19069) 30 years. Resident in hospital 14 months prior to experimentation. Diagnosis: dementia precox, hebephrenic form.

The subject was born of an alcoholic father and a normal mother. One sister is insane. He had great diffculty at school, going only as far as the third grade and failing of promotion several times. At 12 years, he was put to work, and held five positions during the next twelve years. At 24 years he enlisted in the marine corps, where he served five years. After his enlistment, he began to drink to excess and was court-martialed a number of times. He then became subject to periods of depression and four times when depressed attempted suicide by poison. Following his last attempt he was sent to this hospital.

The subject readily became adapted to hospital routine. At intervals he experienced spells of depression, during which he talked very little and was inclined to refuse food. From June 4th to July 10th it was necessary for him to be tube-fed, a process to which he offered violent resistance. Experimental work began June 26th and continued until September 2nd. During the part of this period that he was being tube-fed, the subject cooperated in the tests and answered questions readily, although he spoke very little unless questioned. Later, however, he appeared more interested, and while working at rug-making in August would voluntarily make remarks, although he never conversed freely. In the ward he was normally interested in all that was going on. He did not read, and was most frequently found lying on the seats, sometimes sleeping.

During the preceding two years the subject thought that he was controlled by others, that his thoughts and ideas came from outside sources. He also believed that there had been attempts to do him injury. There were some evidences of auditory hallucinations, but these were not definitely established. During the periods of depression, he became dull and apathetic, was almost inaccessible, and when questioned smiled in a silly manner but gave little information.

Subject B: (Case No. 19949) 36 years. Resident in hospital 15 days before experimentation. Diagnosis: dementia precox, paranoid form.

The subject attended country school between the ages of eight and eighteen, and did well in his classes. He worked in various places until the age of 25, and at one time wandered about as a hobo. He enlisted in the army, where he was twice court-martialed. He was still enlisted at the age of 36, when he gave evidence of the belief that people were annoying him and collecting evidence against him. He was arrested for insubordination and court-martialed. In the guard-house he was found to have perse-

cutory ideas, tactile, auditory, and visual hallucinations. Subsequently he was sent to this hospital.

After admission and during experimentation the subject maintained a constant demeanor. In the ward, he walked around or sat idly and talked at times to himself; he did not read or help with the work and remained by himself almost entirely. He co-operated readily in the performance of the tests, although at first he was prone to interrupt the procedure with a rehearsal of his troubles. He rarely volunteered a remark except about his troubles.

The subject believed that he was held a prisoner at the hospital as the result of a conspiracy of the Roman Catholic priests and the thirty-second degree Masons. These organizations, he believed, were trying to prove him guilty of unnatural practices. Their object in convicting him was to prevent themselves from being exposed by him. He thought that prominent financiers or certain wealthy men were concerned in the affair, and that in some way a number of vessels in the French and Japanese navies were also involved; one of these vessels obtained a crown of diamonds that had been made up for him. His enemies, he said, were doing everything that they could against him, and, wherever he went, were constantly telephoning accusations against him to the people with whom he was. His delusions were very poorly connected and sometimes almost unintelligible, but remained practically unchanged from day to day. He continued to have auditory hallucinations of voices accusing him of immoral practices. He protested constantly that he had been victimized, and that he wished to get out of the institution in order that he might order an investigation.

Subject C: (Case No. 19958) 18 years. Resident in hospital 14 days prior to experimentation. Diagnosis: dementia precox, hebephrenic form.

The subject stated that he had had nervous attacks every summer since he was six years old, and that some of these attacks had kept him in bed as long as three weeks. Between the ages of 6 and 13 he attended school, completing the fourth grade, having failed of promotion twice. At the age of 13, he went to work and continued in various employments until he enlisted in the navy at 17. While on board ship he began to be troubled by the belief that some one was tampering with his mail and that his shipmates were going to 'initiate' him. On one occasion he jumped down a coal chute, stating afterward that his act was part of the 'initiation'. He was admitted to the hospital about a year after his enlistment.

The subject after admission was quiet, neat and orderly. A great part of the time he was employed in the kitchen, where he worked steadily at whatever he was given to do. He was under experimentation from June 26th to September 1st. On July 24th he was granted a restricted parole. On August 1st he began work on the experimental rug-making. In the early part of July, when not employed, he would sit for long times together, taking no notice of anything about him, unless he was spoken to. Throughout August, however, he was much more alert and active, noticed those

who passed, spoke to the physicians, and sometimes played ball on the grounds. He co-operated readily in all the tests, and tried hard, in a childish manner, to please the experimenter. When making rugs, he talked a little with the other subjects, but in the ward he had very little to do with the other men.

The subject reported hearing voices accusing him of sexual vices and insulting him. He was worried a great deal by these voices. He also worried much over mistakes that he imagined he made in his work in the kitchen. Early in the period of experimentation he stated that he sometimes would hear his thoughts spoken aloud, as if someone had the power to read his mind; also that he perceived 'funny odors', which he could not understand, but which he thought indicated an attempt to 'dope' him. These latter delusions disappeared after the first few weeks of the period of experimentation. He always appeared somewhat confused, but answered questions well and intelligently, if questioned carefully and encouraged.

Subject D: (Case No. 19883) 21 years. Resident in hospital 6 weeks prior to experimentation. Diagnosis: dementia precox, catatonic form.

The subject attended school between the ages of 6 and 16, failing of promotion once, and going as far as the first year in high school. After leaving school, he was employed in a number of clerical positions, from several of which he was discharged on account of incompetence. At this time, he stated, his head and eyes bothered him. Later he secured outdoor work and felt better physically. At the age of 20, he enlisted in the navy. Seven months after enlistment, when on shore leave, he spent a night in drinking and in sexual excesses. Returning to the ship next morning, he attracted attention by jumping overboard. For the next few weeks he was unable to answer questions intelligently, talked constantly about sexual matters, and carried out filthy practices with his excreta. He was transferred to this hospital six days after this sudden change in his condition.

During his residence at the hospital the subject had somewhat improved. He was no longer filthy in his acts, did not remove his clothing, and answered questions, for the most part, intelligently, although only after great hesitation. In the ward, he had little to do with other patients, but sat or lay about stupidly for long periods, or walked rapidly about, often waving his arms. In the experimental work he co-operated in general satisfactorily. Sometimes for periods of over a week, the experimenter was not able to get him to utter a word. The mutism appeared, however, not to be due in any way to lack of comprehension, for he obeyed instructions, even those which were not the simplest, promptly and correctly. Sometimes a period of silence would be broken by a well-formed sentence, containing words not included in his usual meager vocabulary. On one occasion, after a two days' silence, the experimenter was questioning him about his inability to speak, when he suddely replied, "I think it is the effect of my environment. I can't talk in an institution for the insane." On another occasion, when he had been found reading a book in the ward, he talked very freely. During

the period of rug-making, he was never mute and frequently, contrary to his customary apathetic manner, expressed his pleasure in the work. It was during this period that it was found possible to get introspections for the maze-learning consciousness from him. At all times he was liable suddenly to become unnecessarily precise in all his movements, thus slowing his times of performance in the various tests. These spells interfered with the rug-making as well as with the other tests. He could sometimes be brought again to usual activity by a sharp criticism and an imperative command to do better.

The subject continued to have hallucinations of voices accusing him of vile acts. He frequently laughed in a silly manner, and when questioned replied, "I don't know why I laughed. I just felt as if I had to."

Subject E: (Case No. 19755) 30 years. Resident in hospital 4 months prior to experimentation. Diagnosis: dementia precox, hebephrenic form; alcohol a precipitating factor.

The subject attended school between the ages of 6 and 10 and got along well. After leaving school he worked on a farm until he enlisted in the army at the age of 18. After his enlistment he began to drink heavily. He re-enlisted three times. When 29 years of age, while in service in the Philippines, he stated that he started out on a hunting trip. While lying awake at night, he heard the voice of his commander, saying that he was going to kill him, because of some immoral thoughts that the subject was having. Thereupon the subject started to return and met natives who looked like little black devils. Upon arriving in camp, he thought that the entire troop wanted to kill him, and he got a gun in order to shoot himself. The gun was taken from him. Later, at breakfast, he seized a knife and cut his throat. He was sent to the hospital, where he continued to hear voices and to have tactile hallucinations, involving his legs and genitals. He was returned to the United States and, while being transferred from the transport, jumped overboard. He was immediately rescued, and was transferred to this hospital about eight months after the first appearance of his altered condition.

After admission the subject was active and interested in the ward, playing cards with the other patients and reading a great deal. On one occasion he succeeded in running away and was brought back. He sometimes helped a little with the ward work. At the beginning of experimentation, he incessantly asked for parole and complained about his imprisonment at the hospital. He took little interest in the tests. Later, however, he came to take a keen interest in the experimental work, trying hard to improve his records. He objected at first to the rug-making, but very soon became much interested in that, also. He no longer complained or asked for parole.

During the first part of the period of experimentation, the subject worried very much over voices, which, he said, spoke to him, sometimes accusing him and calling him vile names, and sometimes directing him to take command of the hospital and drill the patients. He would hear these voices in the chirping of the birds and the sound of the trolley cars, and would sit

and repeat to the experimenter what he imagined they said. In the latter half of the period of experimentation, he ceased to talk of the voices, although he stated that they were still present.

Subject F: (Case No. 19465) 22 years. Resident in hospital 9 months prior to experimentation. Diagnosis: dementia precox, hebephrenic form.

A maternal aunt of the subject was insane. He attended school between the ages of 7 and 14 years, going as far as the seventh grade. He was not apt in his studies and was constantly getting into mischief. He worked on a dairy farm for four years, and then, at the age of 18, enlisted in the navy against the wishes of his father, who told him, the subject states, that he would be sure to go to an insane asylum if he went into the navy. After two years of service the patient reports that he began 'acting kind of funny' and that he laughed a great deal of the time. For these reasons he was transferred to the naval hospital. Some months later he was admitted to this institution.

After admission the subject was conspicuous for his desire to work, working steadily all day about the ward or in the dining room. He worked hard and put a great deal of muscular effort into all his movements. At one time, while employed in the dining room, he annoyed one of the female nurses, and for this reason was returned to the ward. Ten days later he attempted suicide by knocking his head against the wall, sustaining a severe laceration of the scalp. He explained that his action was the outcome of his love for the nurse. Experimentation was begun six weeks after his suicidal attempt. He co-operated well in all the tests with increasing interest throughout and with much enthusiasm for the rug-making.

The subject did not report hallucinations, delusions, or other similar mental symptoms. He was dull and slow of thought, whistled and sang in a mechanical manner while working, and sometimes laughed inanely without cause. During the experimental period this laugh, which the subject could never explain, became less and less frequent, finally becoming of rare occurrence. When questioned about his suicidal attempt the subject, early in the experimental period, would become uneasy, flush, perspire profusely, without answering. Later in the period, however, he spoke of it more freely and laughed about it when speaking of it to other patients. He also mentioned other love affairs that he had had.

Subject G: (Case No. 19804) 57 years. Resident in hospital prior to experimentation, 2 months. Diagnosis: probably dementia precox, although alcoholic deterioration has been suggested.

The subject stated that his father was 'queer' and that a brother had had epileptic fits. The subject attended school between the ages of 3 and 13. Thereafter he worked in the dry goods and upholstery businesses until

the age of 24, when he emigrated from Ireland to the United States. He continued as a dry goods salesman in various parts of the country until he was 51, holding a great number of positions in many different cities. He began drinking at the age of 15, and has drunk very heavily most of his life, although he stated that he had never had delirium tremens. His drinking propensities finally made it impossible for him to continue his usual business. For six years he got along on charity and odd jobs. He was arrested in Washington for disturbing the peace by making a violent and blasphemous speech on the street about the dangers of electricity, and was sent to this hospital.

Upon admission the subject appeared pleased with his surroundings and began to work regularly in the dining room. He was granted limited parole on June 14th. Experimental work began on June 26th. On July 2nd the subject became excited and talkative, and went to the Administration Building complaining that he was being illegally held at the hospital. His parole was taken up. After a few days he became quieter and apparently content. Throughout most of the experimental period he co-operated in the experiments, showing great interest in the tests. On August 1st he began to make rugs. He complained, however, that this was 'woman's work', that he was illegally detained at the hospital, and that he could not be forced to work. He was persuaded to continue until August 7th, when he refused to make rugs or to fill in the cancellation forms, saying that the latter hurt his eyes. He continued to work with the maze, but remained irritable and no longer appeared to take interest in the work.

The subject stated that he 'heard voices' about twenty years ago and that he began to be affected injuriously by electricity ten years ago. He stated that the latter trouble was due to an electric plate in his brain, which had telephonic connection with electric influences outside. He made a great many irrelevant references to electricity in the two excited spells above mentioned. He sometimes talked to himself, but denied that he still heard voices. His memory was excellent, and his general information good. He talked constantly and expressed himself very well for one of his education.

Subject H: (Case No. 19982.) 31 years. Resident in the hospital one week prior to experimentation. Diagnosis: dementia precox, hebephrenic form.

One brother of the patient was neurotic, one paternal graudaunt, insane. The subject received a high school education in Roumania, came to the United States at the age of 19, and worked steadily at photography for the next few years. At 24 he enlisted in the army, where he had severe bronchitis and later a hemorrhage from the lungs. Thereafter he became depressed, worried about his condition, and had auditory and visual hallucinations. He was admitted to this hospital at the age of 28, and was discharged as sufficiently improved seven months later. He went to a soldier's home, but continued to have auditory hallucinations, and for this reason was returned to the hospital 18 months later.

Immediately after his admission the subject worried a great deal about his belongings, which had not been sent with him. He became a little more cheerful later. He was given a limited parole, which was taken up August 6th because he violated the limitations. Experimental work lasted from June 26th to August 22nd. During this time he co-operated in all the tests, although at the beginning of some he refused to do so, until the purpose of the test was partially explained to him. His attention was, however, prone to wander to his worries, and his complaints during the experimental hours were so numerous, that it was decided not to put him at rug-making. Later, however, he asked that he might be allowed to try to make a rug, and he was given the frame of Subject G, when the latter refused to work. On August 22nd, however, he suddenly complained that he was being forced to work, and positively refused either to continue with the rug or to perform the tests thereafter.

Besides the worries mentioned above, the subject was disturbed by auditory hallucinations of voices calling him vile names and sometimes saying unintelligible things. He carried a pad and took notes of incidents that happened during the day, representing the unintelligible voices by geometric designs. He had also very mild persecutory ideas, in that he believed that the other patients tried to hurt him or annoy him.

EXPERIMENTAL PLAN

For all work, except rug-making, the subjects reported for an hour every other day; the interval between the series was, thus, always (approximately) 48 hours. The following tests were performed:

I. Preliminary Tests

1. General tests. For the first two weeks, in order to accustom the subjects to the type of work and to acquaint the experimenter with the individual subjects, tests of a general nature were performed. The results for three of these,—attention, memory span, and apperception,—all of which were performed upon all subjects under the same conditions, will be briefly stated, as it is thought that they indicate to some extent individual differences of the subjects.

2. Directions test. It was thought that a measure of the ability of the subjects to understand instructions would be desirable at the outset.

II. Tests of Motor Control

1. Tapping test, designed to measure the greatest speed at which a simple muscular movement can be performed.

2. Aiming test, designed to measure the accuracy of a simple muscular movement and to determine its dependence upon the speed of the movement.

III. Tests of Learning

1. Kinesthetic memory test, designed to indicate the accuracy of kinesthetic memory of a simple movement.

2. Cancellation tests, designed to test the acquisition of skill in a complicated operation, and the effect of skill acquired in one operation upon the acquisition of skill in another very similar operation.

3. Maze tests, designed to measure the acquisition of skill with and without visual perceptual cues, and to determine as far as possible the part played in the learning by kinesthetic memory.

IV. Learning of a Practical Problem

The subjects were taught to make rugs; their work was quantified and measured as far as possible, for purposes of comparison with the usual laboratory tests of learning already applied.

It will be observed that the tests named above fall into two classes,—tests of motor control, which are pure behaviour tests, and tests of learning, which are more strictly psychological, since they consider, not only the actual performance of the subject, but also the conscious processes involved in learning. It seemed dangerous, when consciousness was to be considered, to rely entirely upon the method of comparative psychology and to infer in the subject the consciousness which we find to be typical in normal subjects. Accordingly, as has already been mentioned (p. 6), an attempt was made, wherever possible, to secure introspections from the subjects.

I. PRELIMINARY TESTS

1. General Tests

a. Attention with simple stimuli. A series of 150 digits[1] was read at the rate of two per sec. to the subject, who was instructed

[1] The series used was the first one given in Franz: *Handbook of Mental Examination Methods, Nervous and Mental Disease Monograph Series* No. 10, 1912, p. 71.

to tap on the table with a ruler whenever the digit "3" occurred. This digit occurred 25 times. One error was scored whenever the subject failed to tap for "3" or when he tapped for some other digit. When the reaction was obviously delayed, so that the subject failed to tap for "3" but tapped for the next number, only one error was counted instead of two. The test was repeated three times. The average error, as a percentage of the total 150 digits wrongly responded to, is shown for each one of the eight subjects in Table I.

TABLE I

ATTENTION TO SIMPLE STIMULI

Subject	A	B	C	D	E	F	G	H
Per cent. error.....	.9	2.7	2.2	16.5	3.1	2.7	2.2	6.4
Rank of subject.....	1	4.5	2.5	8	6	4.5	2.5	7

b. Memory span. The immediate memory span for a series of digits was tested with both auditory and visual stimuli. For the auditory presentation the numbers were read to the subject at the rate of two per sec.; for the visual presentation black gummed letters on a light gray cardboard slide were presented one after the other through a window in a cardboard slide holder[1] at the rate of 2 per sec. The subject was, in each case, first presented with two series of three digits each, then two series of four digits each, then two series of five digits each, and so on up to ten digits. The results are shown in Table II. The memory span was taken as the greatest number of digits correctly repeated, although the first mistake may have occurred for a smaller number. The combined ranking of the subjects for the two series is based on the average span for each subject.

TABLE II

IMMEDIATE MEMORY SPAN

Figures indicate the greatest number of digits correctly reproduced. Stimuli presented serially.

Subject	A	B	C	D	E	F	G	H
Auditory Stimulus.....	7	7	7	5	7	7	7	8
Visual Stimulus.....	5	5	5	3	5	6	5	5
Rank of Subject.....	5	5	5	8	5	1.5	5	1.5

[1] The apparatus was very similar to that described by Franz, *ibid.*, p. 95 f.

c. Apperception tests. The Heilbronner test was used.[1] In this test the subject is presented successively with a series of cards with drawings upon them. The first card has in bare outline the principal parts of an object, the next is slightly more complete, the next still more so, and so on to the last card, which bears the object completed with enough detail ordinarily to insure recognition. Series were used with pictures of the following objects: bicycle, fire-place, fountain-pen, lamp, phonograph, telephone, watch, and windmill.[2] The subject was asked to state what he thought each picture represented or, if he could not do that, to describe what he saw. The results appear in Table III. The degree of apperception for each series is expressed somewhat arbitrarily as the percentage of the cards in the series recognized correctly by the subject. In only one or two instances did these cards fail to be the final consecutive ones for the series. The figures given in the table are the averages of the percentages obtained in this way.

TABLE III

HEILBRONNER APPERCEPTION TEST

Average of *per cents.* of total drawings presented, that were correctly identified in each series of cards.

Subject	A	B	C	D	E	F	G	H
Per cent. identified.....	69.6	42.1	60.9	40.5	58.8	61.1	65.1	82.6
Rank of subject.....	2	7	5	8	6	4	3	1

2. Directions Test

In order to obtain some insight into the ability of the subjects to understand and to act upon simple instructions, they were given the standard "directions tests" prepared by Woodworth and Wells.[3] Both the easy and hard tests were given, the two halves of the easy test being given on different days. All the subjects could read and write, although some hesitated slightly and tended to misread when they did not understand the question. They were told to "do everything that it tells you to do on the

[1] The Ebbinghaus completion test, as described by Franz, *ibid.*, pp. 77 f, proved too difficult for these subjects.

[2] The series are illustrated in Franz, *ibid., pp.* 80-82.

[3] *Association Tests, Psych. Rev. Monograph,* No. 57, 1911, pp. 68 ff.

sheet." They did not know that they were to be timed. Table IV shows the time per reaction (each sheet is supposed to involve 20 separate reactions), and the percentage of instructions incorrectly responded to. With normal subjects the tests should be performed without error, the significant value being the time per reaction. For the precox patients, however, the tests were so difficult that they were in no case done perfectly and the percentages of error were often very high, in spite of the fact that the instructions had not been to work as fast as possible. The ranks given for the subjects in the table are thus based not on the reaction times, which are of minor significance, but upon the percentage of error.

TABLE IV

DIRECTIONS TESTS

For the understanding of instructions. Figures show time in secs. per reaction to instructions and *per cent.* error of the reactions.

Subject	A	B	C	D	E	F	G	H
Easy tests:								
Secs. per reaction.....	15.1	14.6	29.7	14.1	10.2	25.5	16.7	14.8
Per cent. error.....	10.0	17.5	22.5	50.0	22.5	15.0	12.5	2.5
Hard tests:								
Secs. per reaction.....	17.2	19.6	51.0	12.0	12.4	18.5	12.0	15.1
Per cent. error.....	10.	20.	65.	65.	15.	25.	50.	40.
Rank of subject.....	1	3.5	7	8	5	3.5	6	2

II. TESTS OF MOTOR CONTROL

1. Tapping Test

Upon ordinary ruled paper the subjects were required to make dots with a pencil, back and forth across the paper, as rapidly as possible for 30 seconds. The test was performed by each subject on three different days. The average number of dots per second with the mean variation for the three performances is given in Table V. Gatewood, who used this same test with dementia precox patients, calls it a test of "motor efficiency", but observes that a high speed may not be a measure of "motor efficiency" as the performance may be "automatic and not the result of voluntary control".[1] Just when ease of forming

[1] *An Experimental Study of Dementia Praecox, Psych. Rev. Monograph,* No. 45, 1909, p. 63.

automatisms becomes a mark of inefficiency rather than efficiency for the human organism it is not our present purpose to determine. Certain it is that the establishment of an automatic movement, necessary in the performance of such mechanical operations as those with which we are concerned in this paper, is economical and advantageous for the rapid acquisition of skill. Accordingly the subjects have been ranked for speed attained.

TABLE V

TAPPING TEST

Figures show average numbers of dots made per sec. and mean variations for three 30-sec. tests.

Subject	A	B	C	D	E	F	G	H
Dots per sec.....	6.0	4.5	6.0	3.1	6.8	5.4	6.0	6.4
M. V.	±.13	±.68	±.22	±.69	±.30	±.32	±.18	±.46
Rank of subject.....	4	7	4	8	1	6	4	2

The average speed for the eight subjects is 5.5 ± .86 dots per sec. It is interesting to note that this speed is a little greater than that obtained by Gatewood for dementia precox patients, much nearer in fact to the rate found by him for normal subjects. Computed approximately from his curves,[1]—he does not give the data,—the average for five precox subjects is 4.3 ± 1.12 dots per sec.; for four normal subjects, 5.9 ± .6 dots per sec. It is probable, however, that deterioration has progressed farther in Gatewood's patients than in those of the present study. Franz finds for two normal subjects an average of 6.44 dots per sec.[2]

2. Aiming Test

This test, it will be recalled, was designed, primarily, to measure the accuracy of a simple muscular movement, and, secondarily, to determine the dependence of the accuracy upon the speed of movement.

Printed forms were prepared with five circles (18-point capital O's were used) arranged as shown reduced in Fig. 1. The circles were 5 mm. in diameter and were so placed that the

[1] *Ibid.*, p. 65.

[2] *Time of Some Mental Processes in the Retardation and Excitement of Insanity, Amer. Jour. Psychol., 17,* 1906, p. 17.

distance between centers from "1" to "2" should be 50 mm.; from "2" to "3", 75 mm.; from "3" to "4", 100 mm.; from "4" to "5", 50 mm.; and from "5" to "1", 100 mm. The subject was required to take a pencil in the right hand, and with a movement of the whole forearm to make dots, in time with a metronome, successively upon the five circles in the order numbered, beginning over again after marking "5". The exact manner of holding the pencil was left for him to determine.

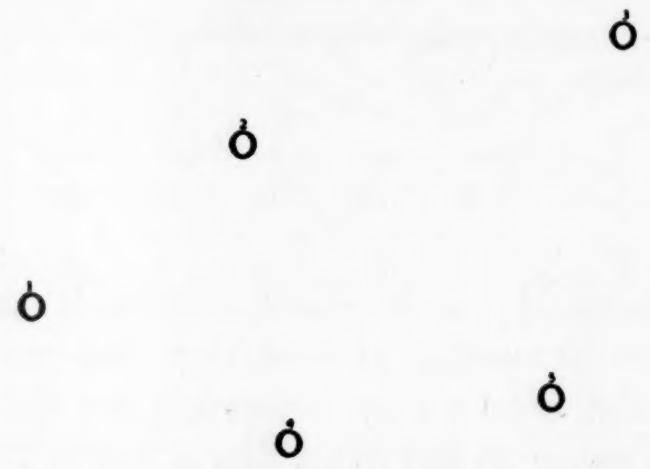


Fig. 1. Target, used in Aiming Test.

Three speeds were used,—1 per sec., 2 per sec., and 3 per sec. The subject made 100 dots on each circle (*i.e.*, 500 dots in all) at each speed on each of six days. Twenty-five dots on each circle were made on each sheet, that is to say, the subject completed the circuit of the five dots 25 times on each sheet. Thus four sheets at each speed, 12 sheets in all, were made each day. In order to balance the effects of fatigue and practice as much as possible, the order of the three speeds was varied from day to day, so that each speed was used an equal number of times in all positions of the series, and was preceded and followed an equal number of times by each of the other speeds.

Before beginning the series, the subjects were practised in keeping time with the metronome at the three speeds, so that they might not find it too difficult when the test was begun. As it was, three subjects found the form used so much harder than the practice form, that they were unable to maintain the highest speed on the first day of the series.

The method employed for scoring the errors was as follows: Any dot lying inside the circle of 5 mm. diameter was counted as perfect. Thus dots on the line were counted perfect. Dots outside the circle, wholly or in part, but less than 5 mm. away counted one error; dots between 5 mm. and 10 mm. from the circle counted 2 errors; dots between 10 mm. and 15 mm., 3 errors; and so on. Thus the errors given represent, not the number of dots outside of the circle, but a moment[1] of error of these dots about the circle.

The method of scoring implies that, when all the dots outside of the circle have been counted, enough more to make 25 must lie within the circle or upon the line of the circle. As a matter of fact careful examination did not always reveal twenty-five distinct points. Sometimes there were as few as eighteen. This was due apparently to the fact that some dots coincided. As long as the coincidence occurs within the circle, no error is introduced; but if the coincidence occurs outside the circle the score is, of course, rendered slightly smaller than it should be. The defect seems to be inherent in the method, as examination with a low power microscope giving a magnification of 25 diameters, showed that two points were always distinguished as separate unless the coincidence was so exact as not to be observable under magnification. It is thought therefore that the error in scoring introduced in this manner is very small. The dots within the circle were nearly always more numerous,—generally very much more numerous,—than those lying within the imaginary ring in which the error was scored one, and since the area of the circle is one-eighth the area of the ring, the chances are very much greater that the coincidence occurred within the circle. Moreover, the likelihood of a coincidence occurring in the area immediately outside the circle is only great when the number of dots falling within it is large; but when this number is large, as it is at a high rate of speed, there are also many dots farther removed from the circle. The total score in such case is apt to be about forty. Very roughly speaking, we would not expect in such a case to find more than six coincidences, four lying within the circle, two immediately outside and none beyond,

[1] The error values are not, strictly speaking, moments about a point. They are the product of the number of dots by their average distance, not from a point, but from a 2.5 mm. circle, expressed in 5 mm. units. It was thought, however, that the term "moment" expressed the significance of the scores better than any other word, and it is used with this explanation.

—for the distribution beyond is always very sparse. The error introduced, then, by coincidence of points would not be greater than 5 per cent. We can perhaps claim no greater accuracy for the method than this. In a similar test Woodworth[1] allowed fifty dots about a single point and counted the outer sixteen. The writer allowed 25 dots about a point and seldom counted as many as sixteen.

The form of the test and method of scoring used were chosen because it was desired, not to make a careful analytical study of the relation of speed to accuracy, but to test in the gross the ability of certain subjects to perform a simple mechanical operation, such as is involved in many skilled occupations, with a certain degree of precision. In any ordinary skilled movement there are limits within which the movement is for all practical purposes perfectly performed. To approximate these conditions, circles were used instead of the points employed by Woodworth[2] and any dot falling within the circle was counted perfect, making an errorless performance quite possible, instead of infinitely improbable. For the same reason, no effort was made to factor the error into a constant error and a variable error. The moment of error used expresses merely the extent of the failure to do the thing required. Again, the circles were arranged asymmetrically, instead of in the equilateral triangle which Woodworth adopted, in order to approximate more closely the irregularity of the componenets of most ordinary movements.[3]

In presenting the results, both in general and for the individual subjects, we shall consider (a) the effect of practice upon accuracy, (b) the effect of the distance moved through upon accuracy, and (c) the effect of the rate of movement upon accuracy.

a. Effect of practice upon accuracy. Each subject made 1500 dots at each of six successive sittings, forty-eight hours apart. It might be expected that the subjects would improve in accuracy with this amount of practice. The variations from day to day

[1] *The Accuracy of Voluntary Movement, Psych. Rev. Monograph*, No. 13, 1899, p. 23.

[2] *Loc cit.*

[3] For the suggestion, that the conditions of the ordinary mechanical operation be more closely approximated by the substitution of an asymmetrical arrangement of circles for a symmetrical arrangement of dots, the writer is indebted to Dr. Franz.

are, however, very erratic for all the observers. If anything, there is a tendency for the error to increase slightly after the first day, due possibly to a partial lapse of the *Aufgabe,* which was evidenced also by an increased tendency on the part of some of the subjects to make remarks while working. They were of course constantly encouraged to do their best, but they found the work tedious and continued attention difficult.

Table VI gives the average error per 100 dots made for all eight subjects. The figures for the individual subjects are not given because they fluctuate irregularly and without apparent significance.

TABLE VI

AIMING TEST

Figures show average error per 100 points for eight subjects at six successive sessions, 48 hours apart. There is no increase of accuracy with practice.

Day	I	II	III	IV	V	VI
Rate: 1 per sec.....	9.7	8.7	10.9	7.8	8.3	8.8
Rate: 2 per sec.....	28.6	36.7	39.1	33.4	34.2	38.7
Rate: 3 per sec.....	82.1	112.2	103.2	88.2	87.5	94.9
Average for 3 rates.....	40.2	51.2	51.2	43.1	43.8	47.5

It thus appears that there is no improvement in accuracy with continued practice under the conditions of this experiment. The failure to improve may be the result of the extreme simplicity of the movement made. It is possible that, in comparatively short times at least, no measurable improvement in accuracy can be made in such a simple movement as the making of a dot upon a certain place upon a piece of paper. Improvement does occur in a more complicated feature of the experiment. Occasionally the subjects made gross errors, such as striking the circles in the wrong order or leaving out a circle. The total numbers of errors of this sort made by all subjects is shown in Table VII. For such a complicated movement as following the irregular order of circles on the paper there is marked improvement with practice.

TABLE VII

AIMING TEST

Figures show total number of gross errors (missing a circle or striking a circle in the wrong order) made by 8 subjects at 6 successive sessions, 48 hours apart.

Day	I	II	III	IV	V	VI
Rate: 1 per sec.....	14	1	0	1	4	2
Rate: 2 per sec.....	1	9	2	1	1	1
Rate: 3 per sec.....	28	14	6	2	0	0
Total for 3 rates.....	43	24	8	4	5	3

b. Effect of extent of movement upon accuracy. In passing about the circuit of the five circles the subject is required to move twice through a distance of 100 mm., once through 75. mm, and twice through 50 mm. It was thought worth while to examine the data in order to determine whether the distance moved through before making a dot had any effect upon the accuracy with which the dot was placed.

Table VIII shows the average error per 100 dots for each of the five circles, calculated for all eight subjects on all six days. The same result is shown graphically in Fig. 2, where the diameter of each large circle is proportional to the average moment of error at that point. The absolute size of the circles is without significance.

TABLE VIII

AIMING TEST

Figures show moments of error per 100 dots and are averages for 8 subjects upon six days; also *per cent.* correlation of distance moved through before point with error at point.

No. of circle	1	2	3	4	5	% cor. for *1, 2, 3, 4, 5,*	% cor. for *2, 3, 4, 5,*
Rate: 1 per sec.....	8.2	8.4	9.9	9.6	9.1	10.3	69.7
Rate: 2 per sec.....	35.3	28.8	39.2	37.0	35.3	50.7	63.7
Rate: 3 per sec.....	66.9	78.9	106.4	111.4	91.5	10.1	89.1
Av. for three rates...	36.8	38.7	51.8	52.7	45.3	23.7	74.2

Examination of the figure would seem to indicate that, in general, the greater the distance moved through the greater the moment of error in making the dot at the point moved to; but that an exception occurs in the case of circle No. 1, where the error is least and the distance maximal. These facts are shown quantitatively in the coefficients of correlation (Pearson method of

'productive-moments') of distance moved through and subsequent error, also given in the table. When all five circles are considered, the average coefficient is 23%, but if circle No. 1 be excluded, the average coefficient for the other four is 74%.

The introspections of the subjects seem to indicate that the conditions for circle No. 1 are not the same as for the other circles. The subjects make such reports as these: "I do the same thing over and over again." "It [the metronome] plays a sort of tune; I'd know it was five without counting." "It's three and then two to me, and then I begin over again." "It's

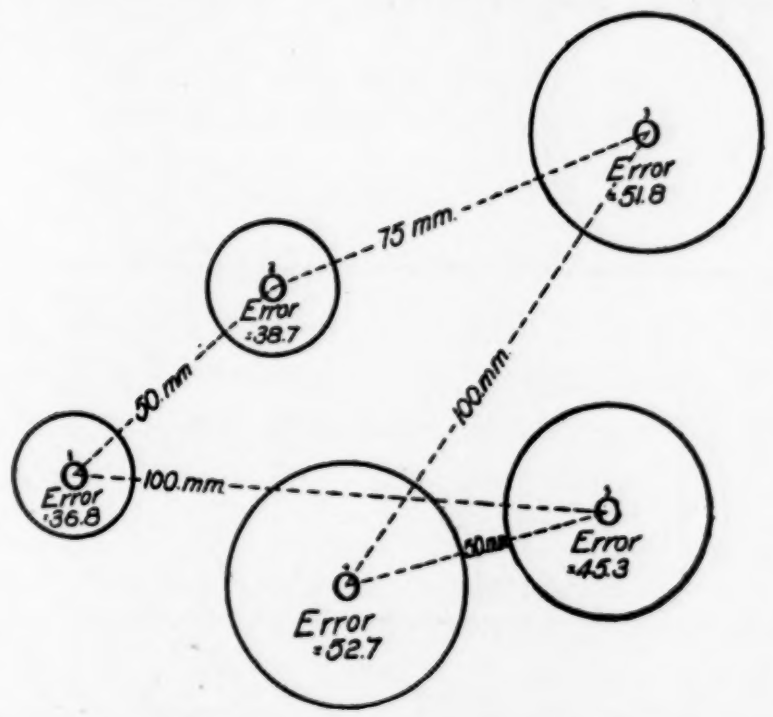


Fig. 2. Errors in Aiming Test. Diameters of circles are proportional to average of 14,500 moments of error for each point. Figures indicate the actual values of the average moments and the distances between points. Note that distance moved through is correlated with size of subsequent error except for 1.

harder to get them good down here [circles No. 4 and No. 5]; I can do it better up here at the start [circles No. 1 and No. 2]." In other words, it appears that the subject conceives that he is beginning over again when he gets to circle No. 1. He does not make 125 consecutive dots, but 25 rythmical units of five dots each, beginning always at No. 1. Sometimes, though not always, it was possible to note a distinct pause before striking at circle No. 1. The writer, in performing the test, found a tendency toward a slight hesitation before striking No. 1 which came as the initial member of a three-two rhythm, toward little better fixation, and, in general, for the whole movement process

to be presented more clearly in consciousness. For these reasons, it seems fair to assume that different conditions apply to the initial point and to exclude it when computing correlations. Thus we find that there is a high positive correlation between distance moved through and subsequent inaccuracy, a relation already much more thoroughly worked out by Woodworth[1], who found that the increase in error was proportional to a value lying between the distance and the square root of the distance moved through, a course intermediate between that which might be expected from Weber's law and that which would accord with the formula of Cattell and Fullerton.

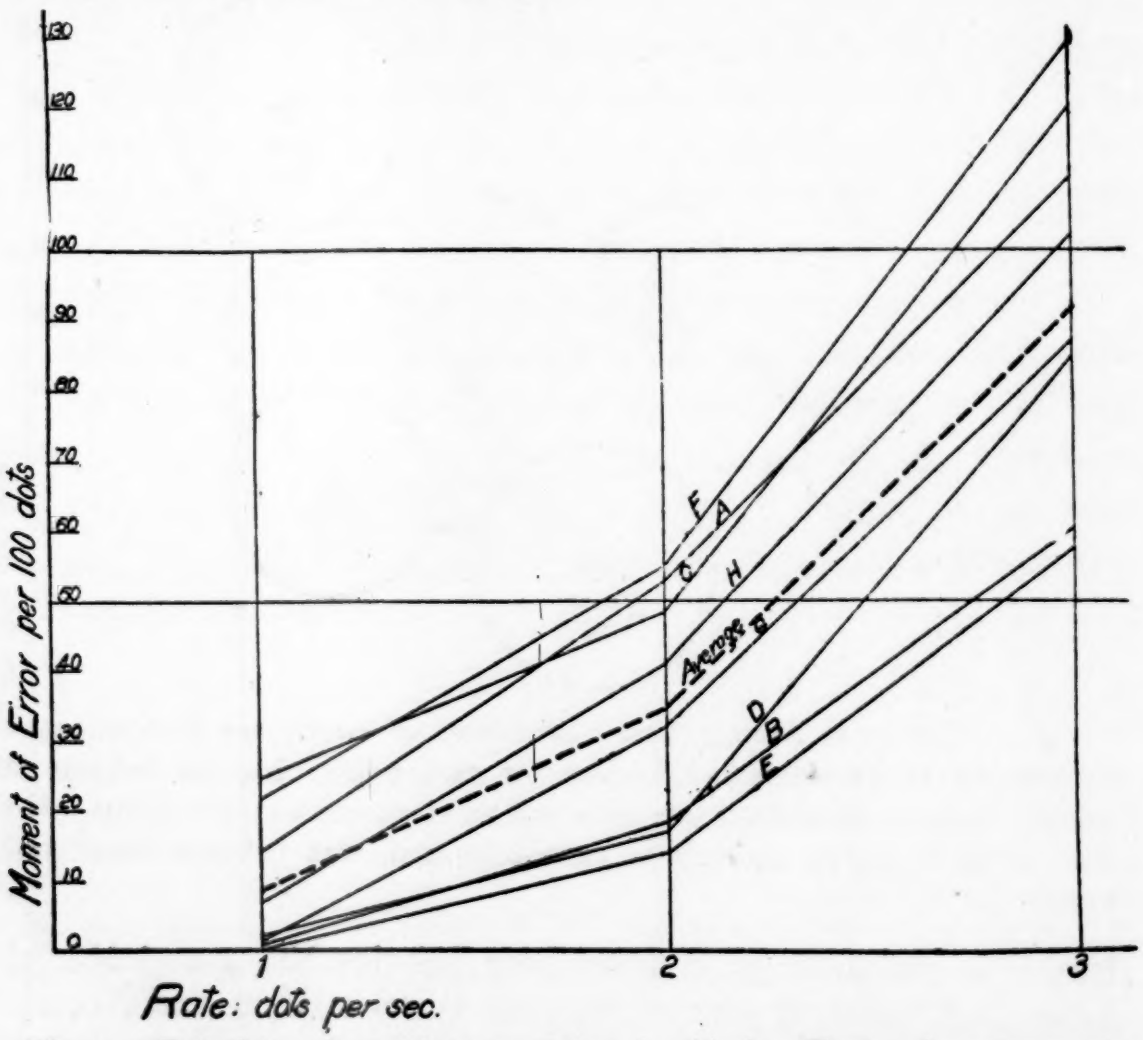


Fig. 3. Relation of speed to accuracy in Aiming Test. Average curve and individual curves for 8 subjects. Three points on each curve.

c. Effect of rate of movement upon accuracy. The relation of accuracy to the speed of movement is shown in Table IX. The figures for each observer are moments of error per 100 dots and are averages of 3000 dots made upon six different days. The averages for the eight subjects also appear. In Fig. 3 these

[1] *Ibid.*, pp. 64 f.

values are platted in curves. It is sufficiently obvious that the error increases with the rate of movement. Just exactly what law the speed-accuracy relation obeys is too difficult a question for us to consider with such meager data as a basis.[1]

TABLE IX

AIMING TEST

Relation of rate of movement to accuracy. Figures show moments of error per 100 dots for each subject, and are averages of 3000 dots made upon six different days.

Subject	A	B	C	D	E	F	G	H	Av. for 8 subjects
Rate: 1 per sec....	72.3	5.4	126.1	10.2	.2	110.9	7.0	34.8	45.2
Rate: 2 per sec....	266.0	94.4	243.4	87.3	71.3	277.4	161.5	208.5	175.6
Rate: 3 per sec....	554.1	304.1	606.3	429.1	292.8	652.8	438.5	513.4	455.1

III. TESTS OF LEARNING

1. Kinesthetic Memory Test

The following test was devised in order to test in as simple a manner as possible, kinesthetic memory, which may be a factor upon which the learning and automatization of a movement depend.

[1] The curves of Fig. 3 have been drawn straight without reference to any theoretical form. One subject (B), who had been doing very consistent work with the test, was tested at eleven different speeds, from 1 to 3.5 per sec. Five hundred dots, distributed over four days, were made at each speed. With one exception they fall along a smooth curve, as is shown in Fig. 4, where the actual curve drawn is that for which the increase of error with the speed is proportional to the square of the speed. It does not follow the direct proportion that would be in accordance with Weber's law nor the square-root-of-the-magnitude relation proposed by Fullerton and Cattell. *Cf. On the Perception of Small Differences* by these authors, 1892, pp. 152 ff. The curve shown here agrees with that found in some cases for the left hand by Woodworth, *op. cit.*, pp. 29 ff. Of course the data are too few for any generalization.

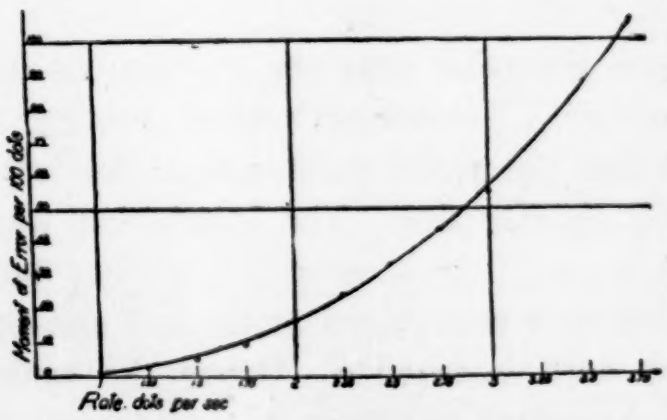


Fig. 4. Speed-accuracy curve for one subject (B) in Aiming Test. 11 points are shown. Curve drawn is that in which increase of error is proportional to square of the rate.

Strips of cardboard were prepared, 250 by 45 mm., and about 2 mm. thick. Beginning near the left end, two parallel horizontal slots were cut, 15 mm. apart, and each 3 mm. wide. On four separate slips the upper slots of the pair were cut 20, 40, 80, and 160 mm. long respectively, and the lower slots, 200, 200, 200, and 240 mm. respectively. A fifth strip with slots 100 and 200 mm. was prepared as a trial card, which was shown first to the subject and upon which he was practised in order that he might become familiar with the method. It was not used thereafter. The procedure avoids the use of any disturbing complicated apparatus. The method is somewhat similar to that of Münsterberg, and of Fullerton and Cattell in similar work.

The subject was seated at the end of a table and a curtain was suspended before his face, extending from the height of the top of his head to the top of the table. The subject could thus place his hand beneath the curtain and write upon the table without being able to see his hand or even any part of the table. To the unaccustomed observer, especially to the easily disturbed dementia precox patient, blindfolding, if tolerated at all, acts as a distraction. The use of the curtain for obscuring the work lacked this disadvantage and proved satisfactory in all other respects.

The cards were laid upon the table near the curtain but on the side away from the subject. The subject's hand, holding a pencil, was then placed so that the pencil point was at the left-hand end of the upper and shorter slot. The instruction was given, "Move as far as you can." As soon as the subject had completed the movement his hand was placed at the left end of the lower and longer slot, with instruction, "Move the same distance." Each card was presented ten times in succession on each of four different days. Twice the shortest distance was presented first and the longest last with the intermediate distances between; and twice the opposite order was used.

In Table X. there appear for each length (1) the constant error, *i.e.*, the amount that the average reproduced length is

greater or less than the stimulus length, (2) the mean variation from the average reproduced length, and (3) the average error of the reproduced length from the stimulus length. For the average of the four lengths the constant and average errors are given in percentages of the stimulus length. The rank of the subject was based upon the average error, since that error involves both the constant and the variable error.

TABLE X

KINESTHETIC MEMORY TEST

Figures show in mm., for 4 stimulus lengths, constant error, mean variation, and average error of reproduced lines, and are averages of 40 trials distributed over four days. Averages of the 4 stimuli are given as a percentage of the stimulus.

Subject	A	B	C	D	E	F	G	H	Av. for 8 subjects
Stimulus: 20 mm.									
Constant error...	8.	5.	15.	4.	3.	2.	8.	8.	6.6
M.V.....	3.0	2.4	8.7	6.3	3.2	1.7	2.8	3.6	4.0
Av. error.....	8.4	4.6	15.1	6.9	3.8	2.5	8.0	8.0	7.2
Stimulus: 40 mm.									
Constant error...	14.	8.	6.	3.	6.	12.	7.	0.	7.0
M. V.	2.9	3.4	3.7	3.7	3.5	5.0	3.3	2.6	3.5
Av. error.....	14.5	8.2	7.3	4.3	7.5	11.9	7.9	2.6	8.0
Stimulus: 80 mm.									
Constant error...	16.	19.	2.	3.	4.	12.	14.	12.	9.0
M. V.	3.8	5.6	6.6	7.9	5.4	11.8	7.3	7.0	6.9
Av. error.....	16.4	18.8	6.4	7.9	6.4	13.8	14.5	13.8	12.2
Stimulus: 160 mm.									
Constant error...	19.	25.	6.	8.	3.	0.	34.	0.	9.8
M. V.	11.0	13.0	12.2	21.0	9.0	10.4	12.2	7.2	12.0
Av. error.....	19.2	25.5	13.9	21.4	10.0	10.4	34.4	7.2	17.7
Av. for 4 stimuli.									
% const. error...	27.	20.	22.	4.	9.	14.	24.	14.	
% av. error.....	28.	20.	28.	17.	13.	16.	25.	17.	
Rank of subject....	7.5	5	7.5	3.5	1	2	6	3.5	

It will be observed in the table that all the observers showed a tendency to overestimate the distance, the average overestimation for the eight subjects varying from 4% to 27%. For the four different lengths this constant error increased with the length from 6.6 to 9.8 mm. overestimation. Expressed in percentage of stimulus, however, the constant error decreases

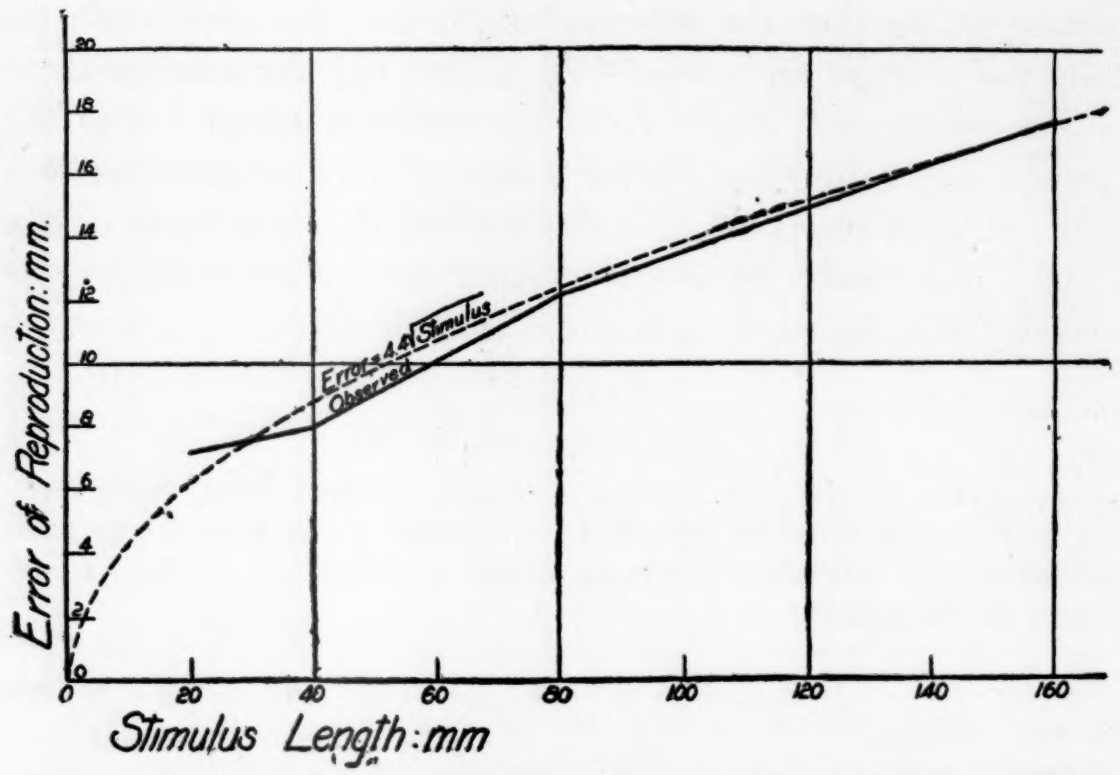


Fig. 5. Kinesthetic Memory. Relation of error of reproduction to stimulus length. Four points. Observed values shown by full curve; theoretical values, in which the error is proportional to the square root of the stimulus magnitude, shown dotted.

from 33% to 6%, as the stimulus increases from 20 to 160 mm. It is possibly caused by the fact that the stimulus movement is checked suddenly and forcibly by the end of the slot. An equal amount of energy expended in the lower slot would carry the pencil further. The absolute values of the mean variations increase with the stimulus length more rapidly, and for the longest length in some cases become actually larger than the constant error. The average error, which depends upon both of these errors, must therefore increase with the stimulus length. The relation of the average values of the average error to the stimulus length is shown in the curve of Fig. 5. Here the four observed points are shown, closely approximating the theoretical relation, in which the error varies as the square root of the magnitude of the stimulus.[1]

2. Cancellation Tests

It was the object of this experiment to test the acquisition of

[1] *Cf.* Fullerton and Cattell, *op. cit.*, pp. 47 ff.

skill in a fairly complicated operation, to determine the character of the operation when learned and the conscious terms in which it was carried, and to study the transfer of practice from the first operation learned to a second operation, in which the motor adjustments remained unchanged, while the perceptual cues were altered.

a. Procedure. Three cancellation forms were used, P and Q as shown in reduced size in Figs. 6 and 7, and a third composed of single digits.[1] All three forms were identical in arrangement, containing eight different characters, each occurring twenty-five times, and placed in the same positions on all the sheets. The

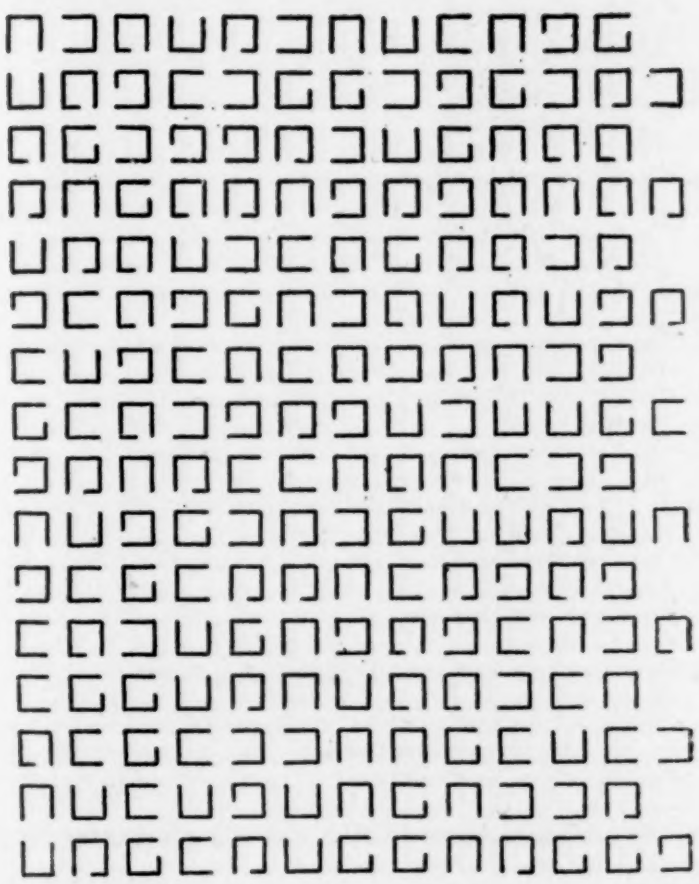


Fig. 6. Form P.; Cancellation Test. Third character from left on top line was cancelled.

symbol selected for cancellation was the third from the left on the top line in each of the two forms shown in the figures. In the digit form the "3", corresponding in arrangement with the second symbol from the left on the top line of the forms

[1] These forms were the same as those used by Kent, *op. cit.*, and are shown by Franz, *Handbook*, pp. 129-132.

shown, was used. Each subject worked, without interruption, on alternate days throughout all the series. On each day he cancelled successively five forms. He used a soft pencil. A copy of the figure to be cancelled was placed before him on a card on a little stand. Errors, both of omission and commission, were marked prominently in blue pencil on each form as soon as it was completed, and the form thus marked was shown to the subject for approximately three seconds, before the subject proceeded to the next.

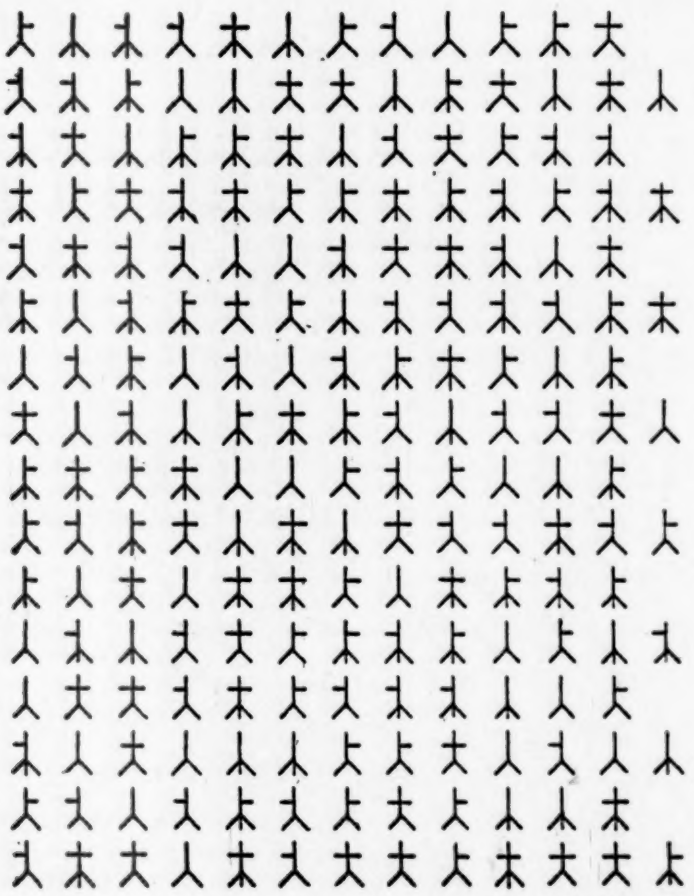


Fig. 7. Form Q; Cancellation Test. Third character from left on top line was cancelled.

The subject knew that the time of his performance was being recorded, and was sometimes told when he had decreased his time. The effect of informing him of his attainment in both accuracy and speed was to establish a double *Aufgabe* to work both accurately and rapidly.[1]

[1] It will be observed that the *Aufgaben* were not the same for all subjects, as some tended to lay greater stress upon improvement in accuracy, others upon improvement in speed, while others held to an intermediate course,—

The digit form was used first in a practice series, which lasted for four days, making twenty sheets in all. It was the object of this series to familiarize the subject with the kind of operation involved—the making of strokes upon a piece of paper in accordance with a visual perceptual cue—so that increased familiarity with the situation would not enter as a considerable factor in learning with the forms following. After the preliminary digit form, four subjects were given form P and four form Q. It was intended to keep all the subjects on these forms until all had become perfect in their performance. Errors, however, persisted with some subjects for such a long time, that it was found necessary to terminate the series for all subjects on the twelfth serial day, when the performance was nearly but not absolutely perfect. Following this series, the subjects were given the form that they had not already used, Q or P, as the case might be. Here they cancelled a different symbol, arranged, however, in exactly the same manner as the symbol they had cancelled in the preceding form. It was desired to see whether the training received with the first form would prove advantageous in learning the second.

b. Learning. Learning of this kind of operation was first evidenced in the preliminary series, the results of which are given in Table XI. The figures given are the averages for the five sheets cancelled on each day. The figures show an average

at least such is the indication of the practice curves; the subjects did not specifically describe the *Aufgaben* under which they were working. For F apparently the *Aufgabe* was changed between series I and II, a result of special instructions given him (p. 35).

It is possible that a more definite emphasis in the instructions of the importance of either accuracy or speed might have brought results from the test, that could have been more easily compared than these actually obtained. The necessity of grading the test for two independent variables and the fact that some subjects improved mostly in accuracy and others mostly in speed made comparison difficult and in some cases impossible (see p. 47). Had the importance of either variable been emphasized to the partial exclusion of the other, it is possible that the factor emphasized might become nearly constant and that the variability of the other factor might better serve as a comparative measure of learning. The writer is inclined to believe that in a repetition of the work he would require each subject to cancel each sheet *correctly* before time was taken, thus making speed the *only* variable.

reduction of time for the eight subjects from 47.6 to 33.7 secs. in the twenty sheets cancelled. For most subjects the errors remain constant; for two (F and H), however, they increase. The average for all subjects thus shows a slight increase in errors,—.6 to .9. The results are comparable to those of Kent,[1] who in twenty-one sheets distributed over seven days found for six observers an average reduction from 54.5 to 41.5 secs. and from .9 to .2 errors.

TABLE XI

CANCELLATION LEARNING

Preliminary series with digit form. Figures show average time in secs. and average number of errors for the five sheets cancelled by each subject on each serial day. All errors are errors of omission.

	Subject	A	B	C	D	E	F	G	H
1.	Secs.	44.8	52.6	54.2	57.6	30.6	43.8	51.0	46.2
	Errors	.6	.6	.2	.4	.4	1.4	.4	.8
2.	Secs.	45.6	47.6	44.6	36.6	26.0	32.0	40.8	44.2
	Errors	.4	.2	.0	.6	.2	1.8	.2	1.0
3.	Secs.	37.4	44.2	46.2	35.0	27.2	26.8	35.4	34.6
	Errors	.4	.0	.0	.2	.4	.6	.4	1.2
4.	Secs.	33.4	41.2	41.8	34.4	25.4	21.2	34.2	38.0
	Errors	.4	.0	.2	.4	.6	3.8	.8	1.6

In series I, following the preliminary series, form P was used with subjects D, F, G, and H; form Q with subjects A, B, C, and E. Series II, in which each subject was given the form not used in Series I, followed Series I by a two-day interval. As has already been noted in the histories of the subjects, G refused to continue the work after the first day, and H after the fifth day of this series. The results for both series appear in Tables XII and XIII, and are represented graphically in the curves of Figs. 8-15. In these curves the average values of both times and errors for each day of the series are shown. Results of Series I are represented by a full line; of Series II, by a dotted line. In examining the curves for evidence of learning, it must be borne in mind that a decrease in time does not necessarily indicate a better performance unless it is accompanied by a decrease in errors. A decrease in time with an increase in errors

[1] *Op. cit.*, p. 388.

or the reverse, a decrease in errors with an increase in time, is equivocal, for there is no way of establishing the value of an error in units of time. Cattell and Farrand[1] suggest adding a proportionate amount of time for the omitted characters in their form, but Wissler[2] thinks that this is not satisfactory. Examination of the curves shows many instances in which a diminution of one factor is accompanied by an increase in the other. This relation is especially evident with subject F, who worked very erratically, sometimes with careless speed, sometimes with laborious care. Note in the curves, for example, Series I, day 5,[3] All of the subjects, however, may be said to have acquired skill in the operation. There is no increase at the end of the series in any case for either factor. The improved performance is however, indicated for some observers principally by a decrease in the number of errors, for others principally by a decrease in time, and for others by diminution of both errors and time. A and E, in both series, and G, in the only series he performed, show learning by a decrease in both errors and time. In both series, C improves chiefly by decreasing the time, B, by decreasing the number of errors. H profits most by lessened time in the first series, but improves in both respects in the second; while D profits chiefly by a diminished number of errors in the first series and improves about equally with respect to both factors in the second, although the improvement in neither case is great. F alone completely reverses his type of learning, showing in Series I a great increase in accuracy with very little decrease in time, in Series II, considerable improvement in time without much change in accuracy. This change followed immediately a reproof at the end of Series I, in which the subject was chided for his carelessness in doing the work. He thus in Series II keeps the error small throughout, consuming much more time in the work.

[1] *Psych. Rev. 3,* 1896, p. 641.

[2] *Psych. Rev. Monograph,* No. 16, 1901, p. 27.

[3] Other examples are: Series I: B-7, 9; C-3, 6; D-11, 12; F-5, 6, 7; G-2, 7; H-11. Series II: D-4, 8; F-3, 6, 8. The letter refers to the subject, the number to the day on which the instance occurred.

TABLE XII

CANCELLATION TEST: SERIES I

Figures show average time in secs. and average number of errors for five sheets cancelled by each subject on each serial day. Errors made by cancelling the wrong character are preceded by a "+". All other errors are those of omission.

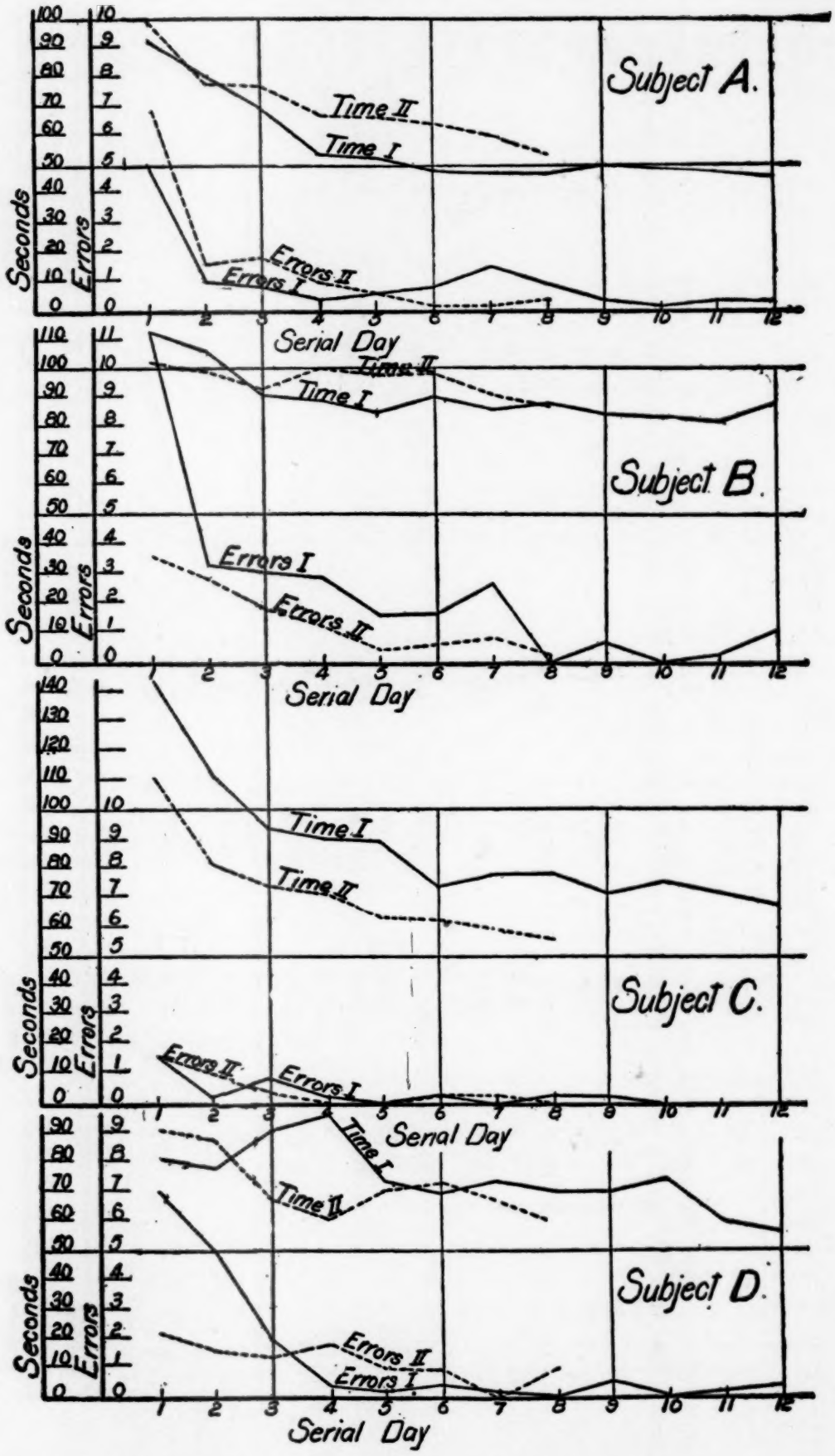
Serial Day	Subject	A	B	C	D	E	F	G	H
	Form used	Q	Q	Q	P	Q	P	P	P
1.	Secs.	92..3	113.4	145.6	81.0	77.2	72.2	104.8	90.8
	Errors	4.8+.2	5.8+5.4	1.2+.4	7.0	.8+4.4	5.4+2.8	1.8	2.6
2.	Secs.	80.4	106.2	113.0	88.6	64.0	62.6	82.6	69.0
	Errors	1.0	2.0+1.2	.2	5.0	2.2+.6	5.6	2.6	1.4
3.	Secs.	69.6	91.4	94.8	91.0	53.6	61.6	71.8	58.2
	Errors	.8	2.4+.6	.8	2.0	1.0	2.4	1.4	.2
4.	Secs.	63.0	89.6	90.0	96.8	46.0	61.4	65.8	61.8
	Errors	.4	2.6+.2	.0+.2	.4	.8+.2	.8	.4	.4
5.	Secs.	52.6	85.6	89.0	74.0	40.2	54.4	56.8	64.8
	Errors	.6	1.4+.2		.2	.8		.6	.6
6.	Secs.	48.4	90.6	74.6	70.0	34.2	61.2	55.2	49.0
	Errors	.8	1.4+.2	.2	.4	1.2	2.8	.2	.2+.2
7.	Secs.	47.6	86.0	78.4	76.0	38.6	67.0	50.2	53.0
	Errors	1.6	2.4+.2		.2	1.0	2.0	1.0	.6
8.	Secs.	47.4	88.6	78.0	74.2	30.8	63.2	42.9	42.4
	Errors	1.0		.2			.6+.2	1.0	.4
9.	Secs.	50.8	84.6	71.4	71.8	28.4	57.8	45.0	39.2
	Errors	.4	.6	.2	.6	.6	.4	.6	.2
10.	Secs.	49.4	83.4	75.4	75.8	30.4	62.2	43.2	39.2
	Errors	.2				.2	1.0	.2	.2
11.	Secs.	48.6	81.8	71.6	62.8	28.2	67.2	41.0	32.6
	Errors	.4	.2		.2		.6	.2	.8
12.	Secs.	47.8	87.8	67.7	58.2	26.6	69.8	42.0	35.4
	Errors	.4	.8+.2		.4		.4		.2

TABLE XIII

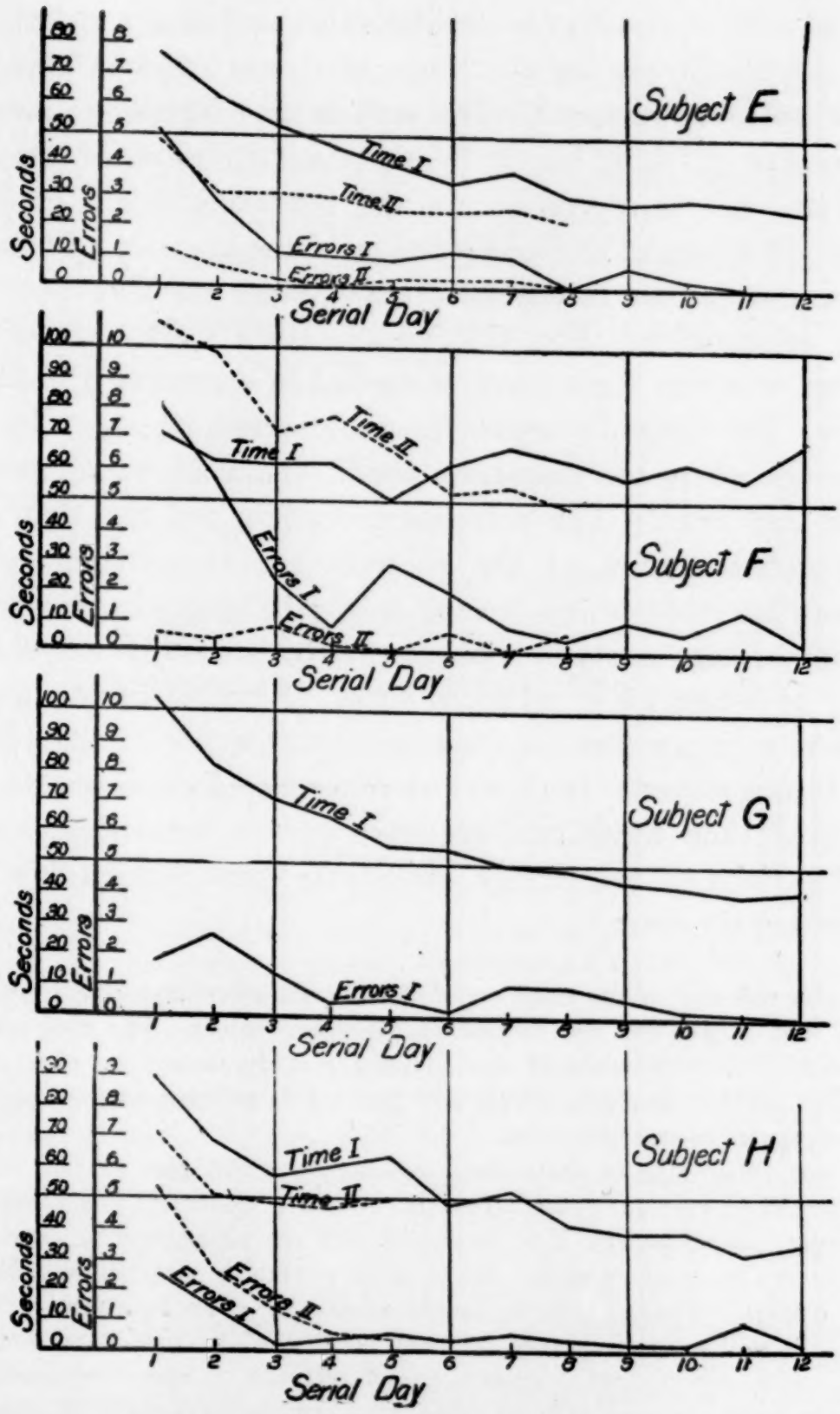
CANCELLATION TEST: SERIES II

Figures show average time in secs. and average number of errors for five sheets cancelled by each subject on each serial day. Errors made by cancelling the wrong character are preceded by a "+". All other errors are those of omission.

Serial Day	Subject	A	B	C	D	E	F	G	H
	Form used	P	P	P	Q	P	Q	Q	Q
1.	Secs.	99.2	102.2.	111.4	91.4	48.6	107.2	125.2	72.8
	Errors	4.4+4.4	3.6	1.6	.8+1.4	1.2	.6	.4	.8+4.6
2.	Secs.	78.4	99.4	82.8	88.8	30.0	98.0		51.6
	Errors	1.6	2.6+.2	1.0	1.6	.6	.4		2.6
3.	Secs.	77.8	93.4	74.6	68.4	30.6	72.4		49.8
	Errors	1.8	1.8	.4	1.4	.2	.8		1.4
4.	Secs.	67.2	100.8	71.8	61.2	29.0	77.8		47.6
	Errors	1.0	1.2		1.8		2.0		.6
5.	Secs.	67.8	98.4	63.0	71.8	25.0	66.2		50.2
	Errors	.6	.2+.2		1.0	.2			.4
6.	Secs.	64.4	98.4	62.0	73.0	25.4	52.6		
	Errors	.2	.4+.2	.2	1.0	.2	.6		
7.	Secs.	60.8	91.6	59.8	68.4	26.4	54.0		
	Errors	.2	.8	.2		.2			
8.	Secs.	54.0	87.0	56.2	60.0	22.4	49.6		
	Errors	.4	.2		1.0		.6		



Figs. 8-11. Cancellation Test. Time and error curves for both Series I and II for subjects A, B, C, and D. Curves for single series show learning. Comparison of two curves shows transfer of practice.



Figs 12-15. Cancellation Test. Time and error curves for both Series I and II for subjects E, F, G, and H. Curves for single series show learning. Comparison of two curves shows transfer of practice.

c. Character of the operation. In considering a test of learning we must deal with the qualitative as well as the quantitative side. Not only must we ask, "How much was learned?", but also, "Just what was learned?" Not only is it of interest to note the acquisition of skill, but it is important to examine also the character of the operation on the conscious side. In some cases, for example, in the discussion of the transfer of training below, the former is dependent in a large measure upon the latter explanation. For this reason notes were kept of the manner in which the subject proceeded in cancelling the forms, and of the subject's replies to such questions as, "Do you remember where the characters are?", "How do you remember where they are?" The notes on procedure and the significant introspective replies of the subjects are summarized below. Where the value of an answer might be dependent upon the amount of suggestion in the question both are given *verbatim,* as far as is possible in a limited space. Some of the replies are so naïvely simple that the introspective accuracy of the subject may be questioned. It should be remembered, however, that at the same time these subjects were giving surprisingly good introspections of the largely kinesthetic consciousness involved in learning the maze.[1]

[1] In this test and in the maze test following we are to examine consciousnesses that accompany the formation of motor habits. For the sake of clearness it is worth while to state definitely at the outset the exact sense in which certain descriptive terms will be used in relation to the particular type of consciousness described.

We are considering in these tests *movements,* which may or may not be accompanied by *relevant consciousnesses.* When a movement is accompanied by relevant consciousness, it is an *action,* and the accompanying consciousness, an *action consciousness.* When a movement is not accompanied by relevant consciousness, it is an *automatic movement* or an *automatism.* Thus, when it is said a "performance becomes automatic" or that "consciousness lapses", it is meant that a consciousness relevant to the movement, *i.e.,* an action consciousness, fails to reappear when the movement is repeated.

The action consciousness, moreover, although only part of a larger total consciousness, is itself complex. It includes certain processes which are relevant to those movements that materially increase or decrease the time of performance of the given operation, and may thus be said to be important for learning. Processes that are relevant to movements which

[The following abbreviations are used: S = subject; Q = question; A = answer; V = statement volunteered without questioning.]

SUBJECT A. *Series I.* S at first goes over every line from left to right. Later, omits going over last line, and finally omits going over first and last three lines except to cancel such figures as occur immediately.

Day 12 (last day). Q. What do you do to find the figures? A. Just look for that [points]. Q. Do you remember where they are? A. No, sir, I don't think I remember at all. Q. Do you know how many are on each line? A. No.

Series II. Procedure as before.

Day 4. Q. Are you beginning to know where they are? A. No, sir. I have to look until I find them.

Day 8 (last day). Q. Tell me just how you find them? A. I look for a square with the right corner out. Q. Do you have to go over the whole sheet to get them all? A. Yes, sir; I go over every line, all but the last two. I know there aren't any there.

SUBJECT B. *Series I.* S goes very slowly from left to right over one line and back from right to left over the next; and so on over the whole sheet, until at the end he omits the last two lines. He often pauses for considerable intervals, as if having difficulty in maintaining attention.

Day 6. V. I think I've found out what's the matter. I've got my mind on the end of the pencil and not on the line.

Day 12. (last day). Q. How do you find them? A. I know about where to find them in the line. Q. When you get to each line, do you think how many there are in it? A. No, sir; not exactly. But in general it appears like I have an opinion where they would be located on a sheet. [In reports on the maze, S identifies 'opinion' with visual and perhaps verbal imagery.]

Series II. Procedure as before. Finally, first line and last two lines are not gone over.

Day 2. S reports he has no notion where figures are.

Day 5. Q. How do you remember where they are? A. By where they're located. Q. How do you know that? A. By the lines. Q. Do you know how many are on each line? A. No.

---

decrease the time of learning are spoken of as *cues,* and these cues may be either sensory or imaginal, perceptual or memorial. If, then, *e.g.,* in learning the maze, the right movement always occurs immediately after the perception of a landmark, it can be said to be touched off by a perceptual cue; if it occurs at the recurrence of an idea of movement at a given time (as is often the case in kinesthetic memory) it can be said to be set off by a memorial cue. Other processes in the action consciousness may not be relevant to the particular character of particular movements, but to the general continuity, speed, uniformity, care, and so forth of the movement; these are spoken of as carrying the *Aufgabe* to keep moving, to move quickly, to be careful, and so forth. They are not regarded as cues, although all the cues may be said to carry a part of the *Aufgabe* to perform the operation perfectly.

Day 8 (last day). Q. Do you know where they are placed? A. No, sir. Q. Take this paper and mark on it as well as you can where you think they are placed. A. I couldn't do it. I wouldn't have any idea where they were. Q. How do you find them when you cross them out? A. I just look for them.

SUBJECT C. *Series I.* S goes over every line from left to right. Later hurries over last two lines, but does not omit them.

Day 8. After four perfect sheets, S makes one error. V. I think I skipped one.

Day 11. Q. How do you find them? A. I look at them all and mark those that have a cross to the left and one underneath.

Day 12. (last day). Q. How do you find them? A. I go over every line except the last. I don't look at that so much.

Series II. Procedure as above, except that last two lines come to be completely omitted.

Day 1. Q. Do you know where they are? A. I know where a couple of them is.

Day 4. Q. Do you remember where they are? A. I generally know where they lay at. Q. Do you know where they all are? A. No. I just know when I get there.

Day 5. Q. How do you find them? A. I look for those with opening at one side underneath.

Day 6. After making an error: V. Seems like I know I missed one. Q. And yet you don't know where they are? A. Oh, yes; I know about where they are, that's how I knew I missed that one.

Day 8 (last day). Q. Do you go over every one of them to find them? A. Oh, not every one. I tend to know about where they are. I sort of expect them.—S is, however, unable to attempt to draw the arrangement on a sheet of paper.

SUBJECT D. *Series I.* S goes over all of each line, from left to right, and continues to do so throughout, although he hurries over the last two lines toward the end. He is mute much of the time.

Day 11. Q. What do you do to get all the figures? A. Just look. Go over each line.

Day 12 (last day). Q. How do you find them? A. I go over each line and check them off when I come to them.

Series II. S goes laboriously over all of every line as before.

Day 5. Q. Do you know where they are? A. I have the picture [of the characters to be cancelled] in my mind and cross them out when I come to them.

Day 8 (last day). Q. How do you find them when you go to cross them out? A. I just cross them out when I come to them. Q. Have you any idea of how they are arranged on the sheet? A. No.

SUBJECT E. *Series I.* On second day S begins to go irregularly from top of sheet to bottom, cancelling two or three lines at once. He improves in this method throughout, until at the end, he spends very little time going over unnecessary parts of the sheet, except for a few lines in the middle. He seems, however, seldom to repeat the same order.

Day 12 (last day). Q. Do you know where they are? A. Most of them; all but some in the middle. Q. How do you find them? A. I know about where to look for them and when I see them I cross them out.

Series II. Procedure exactly as above.

Day 1. V. Runs something similar to other figure. Can locate it pretty easy by remembering how the other went.

Day 3. Q. Have you learned it? A. They follow about the system of the other one [Series I]. Still you have to watch because it's a different figure, and the other figures kind of lead you off. First you check those three, then two, then three in the next row, then three, three, two, one, none, three, three, two, one. [This is correct for the number in the rows, except for one omission.] I don't count them because it takes too much time.

Day 8 (last day). Q. How did you do it? A. I have to watch. I know the arrangement pretty well. I count them off by threes.—S is asked to draw the positions of the characters cancelled on a sheet of paper. This he does with five omissions, placing twenty characters with approximate, although not exact, correctness. He does this quite rapidly, counting them off as he does so.

SUBJECT F. *Series I.* At first S goes over each line, from left to right, slowly. Later goes more rapidly and finally omits last two lines. He seems careless and often misses a whole line. At the end or in the middle, he stops at times and reviews his work, skipping about at random, and hunting for characters missed. Sometimes he spends 30 secs. in reviewing.

Day 12 (last day). Q. How do you find them? A. I know just about where they are located. Q. How do you remember where they are? by the way they look? by the number in each line? A. No, I know just about how they are located, if I don't go too fast; then I get mixed up. Q. How can you tell where they are, though? A. Just go ahead.

Series II. On the first day S goes over all but the first and last two lines, although he will not state that he finds the form similar to last. Thereafter procedure is as before.

Day 1. Q. What helps you to do better than you did with the old form at first? A. Better attention, I guess.

Day 5. V. I know where they're located, but I miss them once in a while. First three rows has got three in a row to cross out, one row's got two, one row one, and there's a pair together.—On one sheet done in quick time for this S, he states that he knows that he has made one mistake, and finds it after eight seconds, thus getting a perfect sheet.

Day 8 (last day). S gives appearance of knowing location of characters, not completing a line when he has crossed out the requisite number for that line. Q. How do you find them? A. I know how many there are in each line and find them that way.—S is asked to indicate on a sheet of paper the arrangement of the characters. He places 23 characters, about the right number, on each line. The first half of the sheet is poorly arranged, the second half quite well. Q. Do you do the form by thinking of some such plan as this? A. Yes.

SUBJECT G. *Series I.* S goes over each line, from left to right, at first. Later, he omits the unnecessary parts of the last four lines.

Day 2. V. I was thinking of memorizing the number on each line.

Day 5. V. I'm beginning to commit the number on each line to memory.

Day 12 (last day). Q. How do you remember the form? A. I remember how many there are on each line. I never counted up, though I say to myself for the lines, "There's one, two, three, then there's three, and then two, and then one." I know how many there ought to be when I look at the line.

SUBJECT H. *Series I.* At first S goes over all lines, from left to right. Later, he goes over all but the last two, either from left to right or from right to left, and sometimes does not complete line after requisite number have been marked. Looks over lines while holding pencil high in air, and appears by pencil movement to anticipate the position of the characters.

Day 10. Q. How do you find them? A. I know the number on some lines. I always have to look for them. Sometimes I get confused because I forget them.

Day 12 (last day). Q. How do you remember them? A. I remember the number in some lines. In a few lines there are three, and somewhere there is only one. I get confused in the middle.

Series II. Procedure throughout like procedure in Series I.

Day 1. Q. Are you beginning to know where they are? A. Yes. Aren't these the same arrangement? I think it because there are three here [points to first three].

Day 2. V. I'm pretty sure the two or three top lines are exactly the same as the last form. I'm not sure all the way through.

Day 4. Q. Do you know where they all are now? A. I know the number on each line.

From the foregoing records, we may conclude that the course of learning is essentially as follows: The subject, while becoming familiar with the appearance of the character to be cancelled, proceeds over the entire form line by line. The first evidences of learning appear both in reduced time and reduced number of errors, coming apparently as a result of increased familiarity with the character. When the subject is perfectly familiar with the appearance of the figure to be cancelled, he may begin to omit lines and parts of lines in which the character does not occur. This he does first at the beginning and end of the form, and last in the middle. Later he may come to remember, either in verbal or visual terms, the number of characters to be cancelled in each line, and follow each line along until he has crossed out the requisite number, or he may become familiar with the grouping upon the sheet, and cross out at once the mem-

bers of a group of two or three, whether on the same line or on adjacent lines. These last two methods are apt to be combined, and the subject seldom applies the same method consistently throughout an entire sheet.

It is quite probable that the process of localization may be resolved into two factors,—a gross factor by which the subject finds the general location of the symbol to be crossed out, and an exact factor, by which he determines the precise position of the character.

The first factor, the general localization of the character, appears at first as a visual-motor adjustment, which enables the subject to follow along from left to right on one line, and back from right to left on the next. Subject D never passed beyond this stage. Later the subject may come to go over all of the lines except parts of the first and last lines. Whether the omission of these parts depends upon a visual, verbal, or kinesthetic cue, the introspections do not show. Subject A progressed only thus far. Next appears a recognition of some or all of the characters when they are cancelled. This is reported by B, C, and E and probably existed for at least F and H in addition. It is apparently the response to a visual perception, and may be assumed to be organic in as far as it involves the feeling of familiarity. E, F, G, and H all came to remember the number of characters in each line. With G the recollection appears to have been verbal; with E and H it was probably either verbal or visual; with F it may have been hand-kinesthesis. The most advanced stage of gross localization seems to be in the grouping of the right characters, a method acquired only by subject E, for whom the groups fell partly in the lines and partly across the lines, and were apparently carried visually, although it is possible that the localization of the whole group upon the sheet was kinesthetic. The writer, who tried cancelling the forms after having become very familiar with their appearance and who was thus able to do them in less time than any of the subjects, also used the group method. For him the gross localization of the groups was carried by eye-strains

and organic sensations in the chest and shoulders. This cue, however, did not enable him to locate the groups except very roughly, say within an inch; all more accurate localization was entirely visual. The reports of all the subjects indicate that for them as well accurate localization of the character was visual. The character might be known to lie in a given region in a number of ways; the indentification of its exact position was, however, always visual.

It must be observed that accurate localization is by far the most important part of the operation for learning. A gross localization may come in verbal, visual, kinesthetic, or attitudinal terms, or may be even automatic, but the operation is by no means accomplished. Sometimes the subjects (especially F) would search over an area of not more than ten square centimeters for a character that it would take two or three seconds to find. The important factor is accurate visual localization.[1]

It is not impossible, of course, that the operation would have become largely a kinesthetic habit had it been continued for a longer time, but that it could be acquired as completely motor any more easily than the operation involved in the playing of a simple piece on the piano in the dark or writing neatly with the eyes shut, the writer doubts.

d. Transfer of practice. In her work with these forms, Kent compares the performance at the beginning of her work with the performance in cancelling another character, similarly arranged, but in a different set of symbols, after two months of work, during which the subject cancelled on still other forms a character in this same arrangement.[2] She finds that out of thirty-eight cases,—these are comparisons of single trials, not of series,—"fourteen show a gain in speed with a loss in accuracy, and

[1] The exact factor has been called 'important', (1) because it is essential to the performance of the operation and (2) because it is more subject to improvement with practice. A form of gross localization is found ready-made, in the almost universal habit of reading from left to right along successive lines. The exact localization, the selection of the right character, is, however, a new act (with unfamiliar figures) and already implies learning during the course of the experiment, if it occurs at all.

[2] *Op. cit.*, p. 395.

eight show a gain in accuracy with a loss in speed," the improvement in these cases being indeterminate, and "sixteen cases show an improvement in both speed and accuracy, while in no case is there a loss in respect to both variables." From this she concludes that "practice effect gained in one kind of work appears to be to some extent transferable to another kind of work which differs from the first in its perceptual but not in its motor aspects."[1] She observes, however, that "it is obvious that the gain may have been due in part to general adaptation as well as to practise transfer."[2]

In the present work it was planned to eliminate the effect of "general adaptation," in the first place, by not beginning the cancellation tests until the subjects were accustomed by other tests to the general kind of work expected of them during the experimental hour; and, in the second place, by introducing a preliminary series of forty trials on the digit form, during which the subjects might become accustomed to the particular procedure required in this test.

The effect of practice, as shown by the two complete series with forms P and Q, can be seen immediately by reference to the curves of Figs. 8-15. With subject F (and also with G, if we consider his one day's work as a sufficient indicator) a decrease in error is offset by an increase in time; with H the reverse is the case; with D, first an increase in accuracy is opposed by an increase in time and later the reverse is the case. All these cases are then indeterminate. An improvement in both variables occurs markedly throughout the course in the case of subject E, and also in the first two days with subject B. Subject C shows an improvement in time with approximately no change in the amount of error. These three can probably be said to show improvement with practice. A, on the other hand, is poorer in both respects for the first five days, after which he becomes indeterminate. Thus, of eight individuals, three (B, C, E) appear to indicate transfer of practice, four (D, F, G, H)

[1] *Ibid.*, p. 409.
[2] *Ibid.*, p. 395.

are indeterminate, and one (A) gives negative evidence of its occurrence.

The question arises: Are these differences due to any difference intrinsic in the forms themselves? The introspections taken on the two forms brought out the fact that the perceptual processes in the early stages of recognition were essentially different. With form P, the subject identifies the character by recognizing the open corner at the lower right hand corner. With form Q, he perceives first the arm on the left with no arm on the right, and then, as a second step in the process of identification, notes the three legs. Sometimes, but not often, the order is reversed, but in any case, it is two or three days before the subject reports, "I see it all at once," a report, taken to mean a grouping into a perceptual whole. It is possible that form Q is thus really more difficult than form P, an unfortunate occurrence, since it happens that all the cases in which form Q was used last, the cases which would form the most reliable index of improvement with practice, are indeterminate cases. Of the four cases in which form P was used last, three appear to indicate that practice has been advantageous to a reduction in both errors and time, and one that it has been disadvantageous; but it now appears possible that the three to one difference may merely be a measure of this difference in difficulty of the two forms. At the best the case is not strong for a transfer of practice,—although the conditions are not greatly different from those of Kent. Possibly her results may have been due to a "general adaptation", as she suggests.

The reason for this absence of any marked evidence for the transfer of learning becomes more evident as soon as we examine the introspections of the subjects. The writer anticipated improvement in Series II because it seemed that a kinesthetic habit formed in Series I would persist advantageously in Series II, even though the visual perceptual cues were altered; and such a persistence Kent apparently assumes to be the case. The introspections, however, have shown that the operation never came to be essentially kinesthetic. The general adjustment to the

particular work, the holding of the pencil so as not to obscure the sight of the lines and yet so as to mark quickly and readily, the keeping of the place on the form, the marking with the pencil, matters of this sort became kinesthetic or automatic very early, probably in the preliminary series, and thus do not affect any comparison of the two main series; but the actual localization of the characters remained predominantly visual, and being visual, only such parts of the visual perception as remained unaltered with the change of form, that is to say, the grouping of the characters, could be effective for an improved performance in the second series. In this connection, it is notable that the one observer (E), who grouped characters over almost the entire page, instead of following out the lines in order to find them, shows by far the greatest improvement in Series II.

e. Comparison of subjects. It is thought worth while to compare the performances of the different individuals in the cancellation work. Accordingly in Table XIV the relative ranks of the subjects in different factors of the test are given. The ranks are based upon the average times and the average number of errors for each subject in Series I, which was the series completed by all individuals. Ranks according to errors and to time are given separately, as it is impossible to combine these two factors satisfactorily. The general performance of the subject is perhaps, however, indicated by the "combined rank," which is based upon the other two rankings,—for time and for errors. The observers were also ranked according to "type of performance," by which is meant the means employed in localizing the characters. In gross localization, it will be recalled (pp. 45f), we recognized five stages: (1) examining all of every line, (2) omitting lines or parts of lines, (3) recognizing characters, but not necessarily anticipating their position, (4) remembering the number of characters on each line in verbal, visual or kinesthetic terms, and (5) grouping characters on the sheets in verbal, visual, or kinesthetic terms. The rank on this basis indicates the number of steps in the typical series through which the subject progressed.

TABLE XIV

RANK OF SUBJECTS IN CANCELLATION TEST

Basis of Ranking	Subjects							
	A	B	C	D	E	F	G	H
Average time	3	8	7	6	1	5	4	2
Average number errors	4	8	1	6	5	7	3	2
Combined time and errors	3.5	8	5	6.5	2	6.5	3.5	1
Type of performance	7	5.5	5.5	8	1	3	3	3

It should be noted in the table that with the exception of subjects C and E the rank position based upon the errors made and that based upon the time do not differ greatly (69.1 % correlation), the subjects appearing to strike about the same balance between the two possible lines for improvement. Subject C, a notable exception, always went very carefully and slowly over his form with fairly good attention. He thus ranks first in accuracy and next to the last in time. It may also be observed that there is some similarity between the ranking according to type of performance and that for time (58.8% correlation). The type of performance and the errors do not appear to be so closely related (13.4% correlation). It is probable that the earlier factors of localization upon which the type is based are those which allow the subject to "speed up" and to hesitate less, but do not make him more sure of avoiding certain persistent errors that remain for some time.

The evidence for the transfer of practice is too dubious for us to attempt to rank the subjects in this regard. They can, of course, be ranked upon the improvement made in respect to time and accuracy separately. Based upon the actual number of seconds or errors saved in the first five trials of the second series from the first five trials of the first series, the orders are as follows: For improvement in time (best subject first), C, E, H, D, B, A, G(?), F; for improvement in accuracy, F, B, E, D, C, G(?), H, A. There is little agreement (a correlation of 11.8%) between the two kinds of improvement.

3. Maze Tests

The cancellation test served for the study of the learning of an operation, which, when learned, involved a variety of

imagery, sensory cues, and automatisms. The maze was selected for learning because it presents an operation that is essentially motor in its performance, that is to say, the accompanying consciousness very soon becomes kinesthetic, and then soon thins out as the movement becomes automatic. Especially is this true when the subject is deprived of the use of vision while learning the maze.[1] The series were therefore arranged so that the subjects might finally traverse the maze without the use of vision, thus making more likely the predominance of the motor character of the performance.

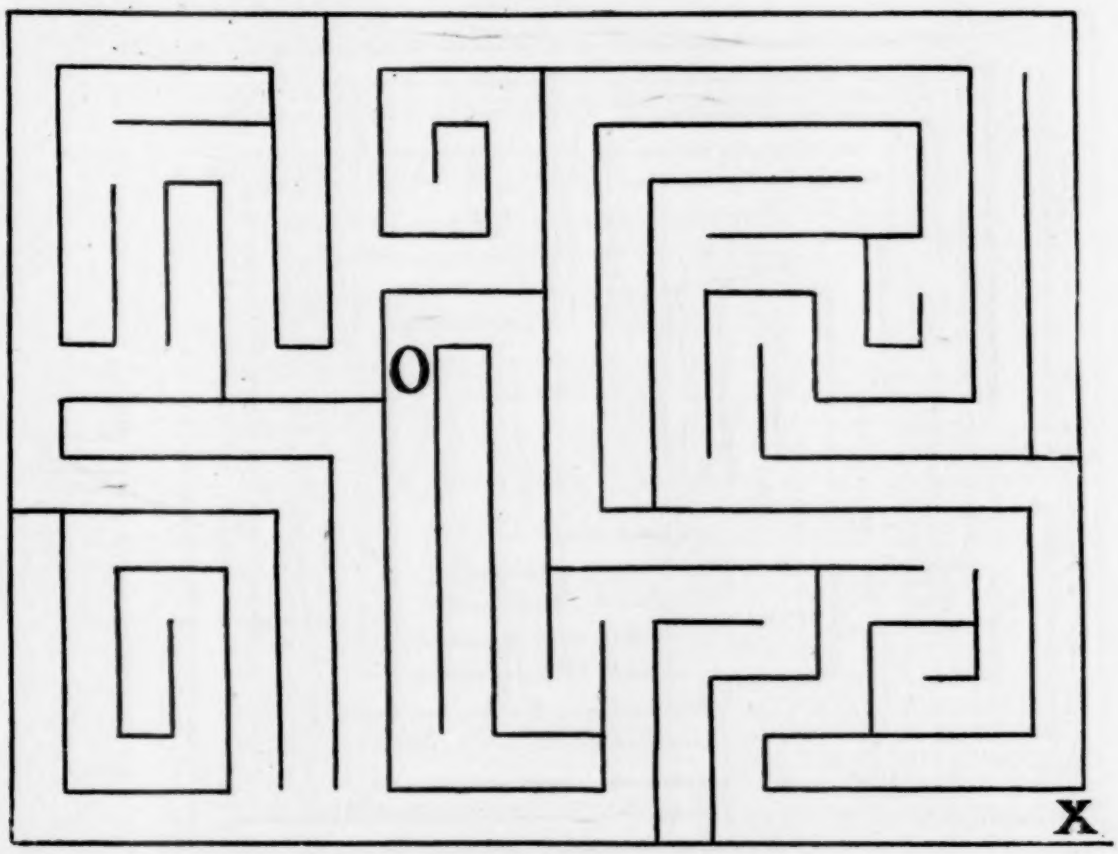


Fig. 16. Maze, used in preliminary practice series. Subject goes from O to X.

a. Procedure. Three series were given. In the first the printed maze form, shown in Fig. 16 was used.[2] The subject

[1] A detailed analysis of the course of consciousness in human maze learning has been made by L. M. Day and the writer, and will be published shortly. The general course of the different imaginal and perceptual factors appears in a preliminary report on this work, *Psych. Bull.*, *9*, 1912, p. 60.

[2] This is the form of maze used by Kent, although only one-half the size of hers.

was required to trace his course directly upon the form with a pencil, starting at "O" and finishing at "X". Since the pencil left a trace he had the advantage of seeing his former mistakes in the same trial. The subject used five sheets at a sitting. The series consisted of four sessions, forty-eight hours apart. Although indicating learning, it was intended only to be preliminary, to familiarize the subjects with the character of the maze problem.

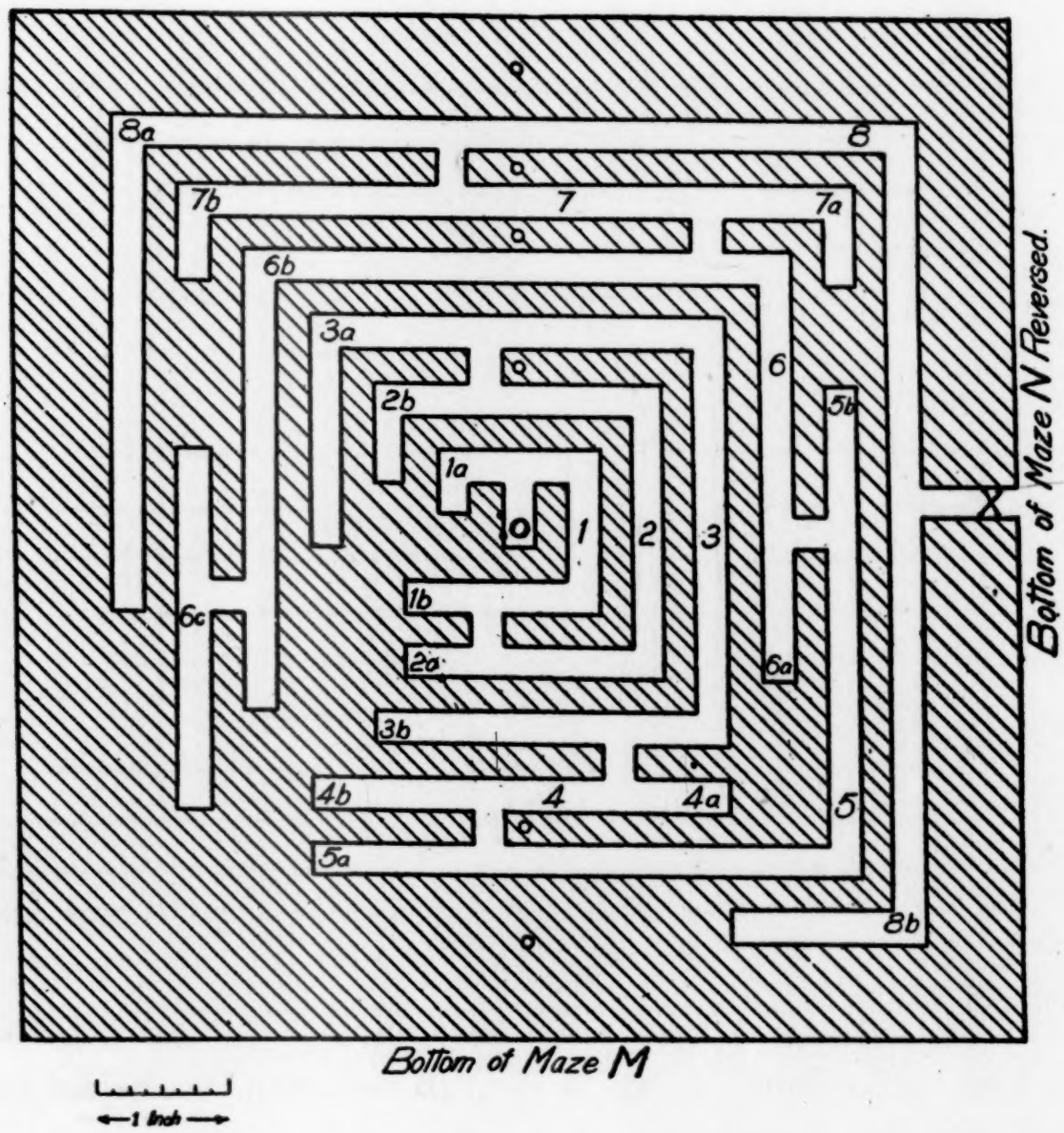


Fig. 17. Maze M, used in Series I. This maze, inverted by turning bottom-side up from right to left and then rotated through 90° in a counter-clockwise direction, forms Maze N, used in Series II. Numbers indicate corresponding passages in either maze. Correct course is "0-1-2-3-4-5-6-7-8-X." Slots in maze are as deep as broad, ¼ inch. Figure ½ full size.

In the first main series, maze M was used (Fig. 17). This maze was cut from fiber, ¼ inch thick. Passages, doors, and walls were all ¼ inch wide. Five small holes along the median vertical axis (see figure) were drilled, so that the maze could be placed upon a wooden base, in which five pins, projecting through the holes, held the maze firm and kept it from springing. In using the maze, sheets of paper with holes punched to correspond to the pins, were placed first upon the base. The maze was then placed on the pins and above the paper. The course was traced by the subject with a pencil, so that a record was left upon the paper, the subject starting in the center at "O" and being instructed to "get out" as soon as possible, the exit being at "X".

The maze was made simple so that the subjects could easily learn to traverse the course without seeing what they were doing. It was not thought, however, that they could readily learn the maze without ever seeing it at all. The series were, therefore, arranged so that trials with the maze in sight should be alternated with trials with the maze obscured from view, the number of trials with the maze in view being regularly reduced, until the course could be followed rapidly and correctly without ever being seen. As in the other tests, five trials were given every other day. On each of the first two days, four trials were made with vision and the final one, without; on the third and fourth days, three trials were made with vision and the final two, without; on the fifth and sixth days, two trials, with vision and three, without; and so on until the ninth day when all the trials were without vision.[1] Thereafter the maze was not seen. The series was continued to include twelve days, even with those subjects who learned most rapidly, thus giving equal amounts of practice to all the subjects before continuing with maze N.

The maze was obscured by the use of the curtain described in the account of the kinesthetic memory test (p. 28), thus avoiding the distraction incurred by blindfolding.

After the completion of series I, the maze was reversed by

[1] Two exceptions to this procedure occur; one, with subject A, day 2, was before the form of the series had been fixed; the other, with subject D, day 6, was the result of a mistake.

being turned bottom side up and rotated through 90° in a counter-clockwise direction. The maze in this position will be known as maze N.

The subjects, now thoroughly familiar with the maze problem from the series with maze M, were required after an interval of from one to five days to learn maze N without seeing it at all. As before, five trials every other day were given. The series was continued in most cases until the subject's average time was reduced below ten seconds.

b. Preliminary series. The results with the printed maze form, used to familiarize the subjects with the maze problem in general, are summarized in Table XV, the figures being averages for the five trials given on each day. It will be observed that all subjects learned this maze readily, and all decreased the average time uniformly from day to day, with the exception of D, who was apt to be erratic.

TABLE XV

PRELIMINARY MAZE. FIGURES SHOW AVERAGE TIME IN SECS. FOR FIVE TRIALS ON EACH DAY

Serial Day	Subjects A	B	C	D	E	F	G	H
1	169.4	108.2	111.8	97.6	53.0	158.0	94.6	75.6
2	53.6	92.4	51.6	52.6	17.8	24.8	46.8	41.8
3	26.6	30.4	50.6	126.2	14.6	12.0	27.0	29.2
4	22.2	18.6	29.4	49.0	15.4	12.8	22.0	22.8

c. Series with maze M and maze N. There appear below the records of the learning of the maze by each subject. It has seemed best to combine the times, the notes on the subjects' performance, and the reports of the subjects, in order that their relation may be more evident. Occasionally interpretations or comments by the experimenter are also included. Since the best illustration of the formation of the motor habit is given by maze N, and since the subjects did not learn to give introspective reports of much value before the beginning of the second series, the reports of maze M will be made as brief as possible; only the points contributing to an understanding of the character of the performance will be included.

Abbreviations Used

In order to economize space the following scheme has been adopted. The letters "a" to "e", placed in parentheses, are used under each day to indicate the five trials on that day. The numbers following them are the times of the respective trials in seconds. The letter "v" (= 'visible") preceding a number indicates that in that trial the subject was allowed to look at the maze, *i. e.*, the visual perceptual cues were present. The letter "i" (= "invisible") indicates that in that trial the maze was obscured by the curtain, *i. e.*, the perceptual cues were presumably[1] only kinesthetic. The letters "v" and "i" are omitted in the consideration of maze N, since all the trials were without vision. After the times for the individual trials there is given for maze N the average for the day. For maze M the average would be without significance. Below the times are given observations, introspective reports, and comments, preceded by the letter of the trial to which they refer. Reports by the subjects were made after the trial referred to. Other abbreviations utilized are: S = subject; Q = question or statement by experimenter to subject; A = answer of subject; V = voluntary statement by subject without questioning or suggestion by experimenter.

Reference is made to definite positions or courses within the maze by means of the numbers shown in sketch of maze M (Fig. 17). In considering maze N, it is not necessary to conceive of maze M as reversed, but merely to take it as it is shown, for the relation of the parts is the same in the two mazes. The reader needs only to disregard the terms "right" and "left", which occur but seldom. It will be observed that the correct course through the maze would be designated as "0-1-2-3-4-5-6-7-8-x". An error always contains a letter, *e.g.*, "4-5-5b" or "7-6-6b-6c". It is possible to traverse the course in five sweeps of the arm, as follows: (1) 0-1-2, (2) 2-3, (3) 3-4-5, (4) 5-6-7-8, (5) 8-x. It can be done in three seconds, perhaps less.

In the following pages the reports for maze M and maze N are given together for each subject.[2]

Subject A

Maze M. Day 1. (a) v 20; (b) v 16; (c) v 13; (d) v 11; (e) i 178.

Day 2. (a) v 11; (b) i 58; (c) i 621; (d) i 748; (e) i 149.

[1] There occurred one instance in which an auditory perceptual cue, the sound of the moving pencil, appeared to be utilized. Doubtless tactual elements were regularly fused with the kinesthetic, although the subjects were unable to distinguish between the two. The use of the term kinesthetic is not meant to imply the complete absence of tactual processes.

[2] As a result of a mistake, for which the writer is partly responsible, the reports have been set up entirely in 11-point type instead of 8-point. This error has the effect of obscuring the summaries for each subject, which were intended to be left in the larger type. The casual reader will find the summaries for each of the eight subjects, separated off from the other matter by leads, on pages 58f, 61f, 67, 70f, 73, 76, and 78.

Day 3. (a) v 11; (b) v 11; (c) v 9; (d) i 76; (e) i 115.
Day 4. (a) v 12; (b) v 10; (c) v 9; (d) i 67; (e) i 51.

(d) Q. How did you remember that? A. I remembered a little bit how it looked. I knew I wasn't going back into the center again. Q. Did you always know what side the next turn would be on? A. No.

Day 5. (a) v 9; (b) v 7; (c) i 42; (d) i 42; (e) i 30.

(c) Q. Did you know the way? A. Pretty much. Q. Could you see how it looked? A. I didn't see it much. I could tell by the touch of the pencil.

(e) S proceeds slowly, feeling walls. "Touch of the pencil" evidently means feeling for doors.

Day 6. (a) v 8; (b) v 6; (c) i 87; (d) i 42; (e) i 26.

(c) Q. Do you remember it? A. Pretty well. I started the wrong way.

Day 7. (a) v 7; (b) i 28; (c) i 20; (d) i 18; (e) i 18.

(c) Q. How do you get out? A. I know to keep to the right all the time. One place where there are two gates together [probably 3-4-5], I try to think when I come to them.

Day 8. (a) v 7; (b) i 88; (c) i 40; (d) i 40; (e) i 25.
Day 9. (a) i 36; (b) i 61; (c) i 41; (d) i 29; (e) i 23.

(a) Q. How did you remember to do it? A. Just remembered. Q. Did you think what it looked like? A. No, sir. Q. Did you think how it felt to do it? A. Yes, sir.

Day 10. (a) i 26; (b) i 20; (c) i 16; (d) i 20; (e) i 20.

(e) Q. How did you know how to get out? A. I just feel with the pencil. Q. How do you know which way to feel with the pencil? A. Just from seeing it the first time; then I followed the way I thought it ought to go. Q. The way you remembered it looked? A. Yes, sir. Q. Do you know what the maze looks like while you are going through? A. No, sir; just think, and feel with the pencil. Q. But what do you think of,—the way it looked? A. No sir, just how to get out.—Note the contradictory answers. S is apparently quite suggestible. The last answer, which is not the suggested answer, would seem to indicate that the movement is becoming motor. S is asked to draw the maze on a separate sheet and does so, puzzling very much over the task and making at least five important errors. Q. Do you think now after drawing the maze that you could get out by remembering how the maze looks? A. No, sir; I get out by just following the pencil. I feel along and follow the pencil.—Evidently the operation is kinesthetic.

Day 11. (a) i 22; (b) i 15; (c) i 14; (d) i 21; (e) i 14.

Day 12. (a) i 12; (b) i 11; (c) i 10; (d) i 15; (e) i 16.

Maze N. Day 1 (a) 510; (b) 237; (c) 252; (d) 253; (e) 457. *Av., 341.8.*

Day 2. (a) 96; (b) 183; (c) 57; (d) 65; (e) 43. *Av., 88.8.*

S moves slowly and makes only three or four mistakes each trial.

(c) Q. How do you remember how to get out? A. Just try to study how to get out. Q. What do you think about? A. Don't know, sir; it just comes in my mind to try to get out. Q. Do you keep thinking about the way the maze must look? A. No, sir, not at first; after I've felt my way around I try to think how it looks—how to get out. 'Thinking how to get out' is perhaps equivalent to visual imagery for this subject.

(e) Q. Do you still do this by studying? A. I try to think how it looks after doing the other. I get out that way. Q. Do you think all the time you're trying to get out how it must look? A. Yes, sir.—The process must be largely visual.

Day 3. (a) 67; (b) 25; (c) 27; (d) 29; (e) 36. *Av., 36.8.*

(a) Q. How did you remember it? A. Don't know, sir. Just felt my way.

(b) Q. Was that easier? A. Yes, sir. I tried a different way. Q. How was it different? A. Different passageways. Q. Was it different all over or just at one place? A. All over, sir.

Day 4. (a) 116; (b) 49; (c) 64; (d) 33; (e) 21. *Av., 56.6.*

(e) Q. Do you think you know the way? A. I'm not quite certain where to turn.

Day 5. (a) 34; (b) 28; (c) 21; (d) 18; (e) 17. *Av., 23.6.*

(e) Q. Do you know it pretty well? A.Yes, sir. Q. How do you remember it? A. I just feel with the pencil in the passage. Q. Does that tell you how to turn? A. No, sir. Q. What does? A. I just feel, if I can't get out one way, and then come back and go the other.

Day 6. (a) 24; (b) 25; (c) 19; (d) 19; (e) 15. *Av., 20.4.*

(a) Q. How did you remember that? A. I just knew how to go. Q. Did you think how to turn at each door? A. No, sir; I just did it naturally. [Expression 'did it naturally' may be borrowed from rug-making introspections, given by S on preceding day.] Q. Didn't you know where you were going to turn before you did turn? A. No, sir. [Positive.]

(b) Q. How much did you think about that? A. I wasn't thinking much about it. Trying to keep going, that's all.

Day 7. (a) 20; (b) 19; (c) 15; (d) 13; (e) 16. *Av. 16.6.*

(e) Q. How was that? A. I keep feeling for the doors and

go to the left. Q. Is that all you do? A. Yes, sir. Q. Could you draw a picture of the way you go? A. I don't know [appears very doubtful].—Apparently the habit is largely kinesthetic, not yet automatic.

Day 8. (a) 15; (b) 11; (c) 14; (d) 11; (e) 10. *Av., 12.2.*

(a) Q. Did you know that well? A. Yes, sir. Q. How did you know it? A. Just by the gates. I judged it. Q. Where the gates would be? A. Yes, sir.

(e) Q. How did you do it? A. Just came to the right, feeling for the passage. Q. Is that all? A. I can't explain it. I just kept on feeling for a door, but I can't explain how it was.

Day 9. (a) 13; (b) 9; (c) 13; (d) 9; (e) 8. *Av., 10.4.*

(e) Q. What did you think about? A. I don't know. Just hunted for passageways. Q. When you made a turn did you think which way to go? A. I don't know.—S is urged to answer. A. Well,—it's just from practice,—doing it so often I get used to it.

Day 10. (a) 12; (b) 9; (c) 8; (d) 8; (e) 14. *Av., 10.2.*

(e) Q. What helped you to get out? A. I don't know how to explain it, sir. It was just feeling for the gates and thinking where they must be from practice. Q. Did you think much about it? A. Not very much.

Day 11. (a) 9; (b) 11; (c) 8; (d) 8; (e) 7. *Av., 8.6.*

(e) Q. How did you remember it? A. Just by feeling, sir, and practice. Q. Did you have to think much about it when you were going through fast? A. No, sir; not much. Q. Did you think about it at all? A. Yes, sir; I knew I was going through.

Day 12. (a) 9; (b) 8; (c) 9; (d) 7; (e) 6. *Av., 7.8.*

(e) Q. What did you think about while you did it? A. I don't know, sir. Just think about how to get out. Q. Did you think how to make each turn, when you came to it? A. No, sir. I just kept along the side of the walks and ran into the passageways. Q. When you went through a passageway did you always have to think which way to turn? A. No, sir. I did it from practice. —S is asked to draw his course on a separate sheet. He does it poorly with three important errors. Q. Did you ever think that this maze was anything like the first one? A. No, sir. I knew it was different.

We may conclude then, that for subject A the operation with maze M was first of an uncertain character becoming largely kinesthetic about the ninth day. The movement does not become automatic, although quite probably those factors connected with

the determination of the course become less prominent than those carrying the *Aufgabe* to get through (*cf.* "trying to keep going", day 6). With maze N, the operation is accompanied by visual imagery at first. The kinesthetic factor enters as prominent about the third day, and the visual factor has largely disappeared about the sixth day. The process is perhaps already somewhat automatic, and becomes more so, although not entirely so, later. The *Aufgabe* appears to be carried consciously, perhaps in kinesthetic terms.

Subject B

Maze M. Day 1. (a) v 20; (b) v 9; (c) v 7; (d) v 7; (e) i 178.

(e) V. That's more guess-work than anything else. Q. Did you have a picture of it in your mind? A. No, sir.

Day 2. (a) v 8; (b) v 7; (c) v 6; (d) v 5; (e) i 18.

(e) Q. Do you always know where you are? A. I have an idea where I am. Q. Do you think of how the maze looks? A. I had an imagination of it.

Day 3. (a) v 6; (b) v 5; (c) v 5; (d) i 77; (e) i 33.

Day 4. (a) v 6; (b) v 5; (c) v 5; (d) i 20; (e) i 60.

Day 5. (a) v 5; (b) v 4; (c) i 42; (d) i 33; (e) i 110.

(c) V. I was lost. I didn't get started right.—Has S already a motor habit which must go off continuously in order not to be broken up?

Day 6. (a) v 6; (b) v 5; (c) i 26; (d) i 48; (e) i 95.

(d) Q. How did you remember it? A. General imagination. General opinion of the way it is.—Continued questioning of S seems to indicate that a 'general opinion' means visual imagery, but this is not positive.

Day 7. (a) v 4; (b) i 45; (c) i 28; (d) i 13; (e) i 13.

Day 8. (a) v 5; (b) i 38; (c) i 10; (d) i 9; (e) i 7.

(e) Q. How do you remember how to go? A. I just have a general idea. Like looking at a picture in the dark when you can about half-way see it.

Day 9. (a) i 12; (b) i 12; (c) i 10; (d) i 20; (e) i 13.

(e) Q. How do you remember it? A. Just imagination. Q. Tell me what you mean by imagination. A. Looking at something in the dark, not clear dark; having a general opinion of it. Q. Does feeling help you to get through? A. No. sir; except as I can generally tell when I run by a gap.

Day 10. (a) i 85; (b) i 27; (c) i 32; (d) i 36; (e) i 20.

(a) V. When I make a mistake I try to go back to the center and get started right.

Day 11. (a) i 11; (b) i 16; (c) i 12; (d) i 12; (e) i 1.

(a) V. I had a very good imagination all through. Q. What do you mean by imagination? A. Just a general opinion of it; something like looking at a map.

Day 12. (a) i 12; (b) i 11; (c) i 10; (d) i 10; (e) i 9.

Maze N. Day 1. (a) 44; (b) 31; (c) 74; (d) 74; (e) 59. *Av., 56.4.*

(b) Q. Does the old maze help you in this? A. The only way I can form an opinion of it is that it's just the same as the other one, only you form it in the opposite direction.

Day 2. (a) 210; (b) 76; (c) 138; (d) 1012; (e) 50. *Av., 297.2.*

(a) V. No idea of it at all. I can't get my mind on it at all.

(d) S goes repeatedly as far as 5b and returns without making 6. He says repeatedly, "you can't get out except by going away from the center." After many minutes he is finally instructed to "feel *all* of *both* sides of *all* passages". At last he goes 5-6 by accident.

Day 3. (a) 115; (b) 30; (c) 108; (d) 43; (e) 30. *Av., 65.2.*

Day 4. (a) 27; (b) 26; (c) 34; (d) 59; (e) 18. *Av., 32.8.*

(b) Q. Try to remember next time how you remember how to go.

(c) While running course: V. I think that's where I have to go the other way [5-6]. Afterward: V. It's very much the same as if I saw the way it looked. I knew where I had made a mistake before and had to turn back toward the center.

(e) V. I got out quicker than I thought I would. [Motor?]

Day 5. (a) 14; (b) 22; (c) 12; (d) 13; (e) 11. *Av., 14.4.*

(a) Q. Did you know how to go? A. Yes sir. Q. A general opinion [= visual imagery; see above]? A. No. Q. Did you think much about it? A. No, sir. Went right through.

(c) V. I knew exactly where to go. Didn't have to bother over it.—Apparently an abrupt change to kinesthetic consciousness, perhaps automatism.

Day 6. (a) 11; (b) 10; (c) 11; (d) 25; (e) 14. *Av., 14.2.*

(d) S goes wrong, 6-6b; returns 6b-6-5, and then back 5-6-7 and out. V. I was miscalculating inside route. Q. How did you get out then? A. I knew where to come back to and get started over.—It seems that S returned to 5 to get a 'running start' to take him out, a characteristic of a motor habit.

Day 7. (a) 15; (b) 9; (c) 21; (d) 16; (e) 8. *Av., 13.8.*

(e) Q. Did you think about it at each turn? A. I knew how to go. Q. You know how to tie your shoe, but you can do it without thinking much about it. Was it like tying your shoe? A. No, I don't think so, I had it on my mind all the time. I could tell in imagination how to go each time.

Day 8. (a) 15; (b) 9; (c) 11; (d) 12; (e) 9. *Av., 11.2.*

(e) Q. How do you remember it? A. I have it in my mind where the gaps are. Q. When you get through one do you always think that you've gone through? A. Yes, sir; and I know where to get the next one.—Certainly the performance is not automatic, although, since S no longer has a 'general opinion', it may be kinesthetic.

Day 9. (a) 19; (b) 17; (c) 8; (d) 10; (e) 10. *Av., 12.8.*

Day 10. (a) 14; (b) 15; (c) 11; (d) 11; (e) 8. *Av., 11.8.*

Day 11. (a) 12; (b) 9; (c) 33; (d) 7; (e) 8. *Av., 13.8.*

S has given practically the same report for the last three days as for day 8.

(c) S has same trouble at 5-5b as on day 2.

Day 12. (a) 14; (b) 10; (c) 6; (d) 12; (e) 8. *Av., 10.0.*

(e) Q. How did you do it? A. Just knew how to go through. Q. What do you mean? A. I don't think I could set down and mark with a pencil how to go perfectly. But somehow when I get in the passages it just seems I know how to go to get through. Q. Can you see the formation of the maze now in your mind? A. Yes, sir. Q. Do you or don't you think about that while you are going through? A. I do and I don't. I see it some, but then again I don't see exactly where all the doors are. As I go through the curvature [S moves hand as if to indicate the turns of the maze] gives me some idea of how to go.—S is able to draw the maze now with three important mistakes. He is not certain how correct it is. Apparently he is running the course, dependent chiefly on kinesthetic cues, even if visual imagery is present.

Maze M is done by subject B apparently in visual terms throughout, although there is some intimation of a motor factor toward the end (tenth day). He recognizes maze N as the reverse of maze M, but has great difficulty with it. On the fourth day he is given the *Aufgabe* to introspect and reports visual imagery. In the last trial, however, a motor factor seems to appear, and the following day the performance is definitely kinesthetic. There is no indication of its becoming automatic up to the end. Some visual imagery appears to be present throughout,

but this seems not to be essential for the determination of the course. It may partially carry the *Aufgabe*.

Subject C

Maze M. Day 1. (a) v 35; (b) v 14; (c) v 12; (d) v 10; (e) i 187.

Day 2. (a) v 9; (b) v 8; (c) v 7; (d) v 6; (e) i 141.

Day 3. (a) v 6; (b) v 6; (c) v 5; (d) i 19; (e) i 197.

(d) Q. How did you know how to get out? A. I could tell which way to turn generally. Very near knew where the doors were. Could tell by whether my hand was near center whether I had gone too far.

Day 4. (a) v 5; (b) v 4; (c) v 4; (d) i 27; (e) i 27.

(d) Q. How do you get out? A. I know when I'm in the center. I can't force my way out; I think I think what the drawing looks like.

Day 5. (a) v 5; (b) v 6; (c) i 17; (d) i 43; (e) i 28.

Day 6. (a) v 4; (b) v 4; (c) i 68; (d) i 16; (e) i 12.

(c) S starts out rapidly, but cannot, at first, get beyond 2-3-4a. V. I dreamed last night that I was drawing it and thought I knew it.

Day 7. (a) v 5; (b) i 17; (c) i 26; (d) i 14; (e) i 14.

(e) Q. How do you do it? A. I know it in my mind. Q. Do you see a picture of it in your mind? A. No, I don't. I just keep thinking I want to get better.—Futher questioning fails to distinguish between 'knowing it in mind' and 'seeing it in mind'.

Day 8. (a) v 4; (b) i 38; (c) i 20; (d) i 29; (e) i 31.

Day 9. (a) i 15; (b) i 36; (c) i 18; (d) i 14; (e) i 18.

(e) Q. How did you remember how to go? A. Seems like I've been so used to drawing it I see it right in front of me. No, of course I don't see it, but I imagine it. One place I get mixed up. I know I'm wrong. Q. How do you know you're wrong? A. I don't know; I just can't find the gate. When I get in the long path [8] I know where I'm at. Q. How do you know you're right then? A. I just find I can go a long ways when I'm in it and I know I'm right. Q. Do you generally see the next gate in your mind before you get to it? A. No. Q. After you get to it? A. Yes, I see it then.

Day 10. (a) i 18; (b) i 19; (c) i 19; (d) i 15; (e) i 15.

(a) V. I know it most all from the beginning. Q. How do you remember it? A. I start in the center and go like that.—S draws with finger on table, accompanying drawing with words, "up, down, up, down". Q. Do you see the course in your mind? A. Seems like I sort of see it.

(e) S is instructed to draw course on a separate sheet. Starts twice and gets confused. Then: V. Seems like I could do it better with my eyes closed.—S draws it readily third time behind the curtain making errors in 0-1-2-3, but not in the rest. Q. Why is it you draw it better with your eyes closed when you think the way it looks is what helps you most to get out? A. I don't know. I do sort of see it. Q. Did you have a picture of it in your mind when you drew this [the reproduction of the course]? A. Yes, sir. I sort of saw it. It's that way when I'm reading. I see things if I shut my eyes.

Day 11. (a) i 15; (b) i 14; (c) i 17; (d) i 14; (e) i 17.

Day 12. (a) i 14; (b) i 13; (c) i 13; (d) i 13; (e) i 15.

(e) Q. How did you remember how to get out? A. Seems like I knew it was perfect. I draw right along. Q. What is in your mind when you're drawing right along? A. I'm thinking about my pencil and moving; and sometimes I get mixed up in the doors there. Q. Do you think about the way the passages look? A. Yes, sir. Q. Of the way it feels to go round? A. Yes, sir; it's more by the way it feels.

Maze N. Day 1. (a) 224; (b) 457; (c) 105; (d) 53; (e) 71. *Av., 182.0.*

Day 2. (a) 36; (b) 49; (c) 44; (d) 30; (e) 29. *Av., 37.6.*

(a) Q. Do you remember how to go? A. Yes. After I get to one door on the left, I seem to know where I'm at. Q. Is it a long ways out after that door? A. Yes, I have to make several turns. I come right out too.—Perhaps the door is 2-3.

(e) Q. How did you remember how to get out? A. Seems like you just keep your pencil going like. It doesn't pay to stop.

Day 3. (a) 48; (b) 28; (c) 22; (d) 23; (e) 21. *Av. 32.4.*

(b) How did you remember it? A. It sort of comes to my mind when I get to each place. I kind of know how to go.

(c) Q. Was that like last time? A. Yes. It seems like the more my pencil goes through one passage, the more I know where I'm at the next time. Q. How do you know where you're at?—S is puzzled. Finally: A. Don't know; I just sort of feel with my hand where the next door is going to be.—Apparently the performance is already kinesthetic.

(d) V. I just keep on moving my hand about and it seems like I get out.

(e) Q. Is that the same? A. Yes, sir. Only when my hand stops going, then I think of it. It doesn't pay to stop. Then I run over the same line. Q. Why do you go over the same line? A. The stopping mixes me up.

Day 4. (a) 69; (b) 26; (c) 28; (d) 20; (e) 17. *Av., 32.0.*

(e) Q. When you go the right way in a turn, do you think how to do it? A. No. Q. Do you do it without thinking about it then? A. No, not that either. It seems like my hand was just going with the pencil. Sometimes when I go wrong I think more about it.

Day 5. (a) 27; (b) 26; (c) 17; (d) 19; (e) 16. *Av., 21.2.*

Day 6. (a) 20; (b) 23; (c) 17; (d) 17; (e) 15. *Av., 18.4.*

(a) V. I remembered it pretty well at that time. It seemed like the way my hand was going round, I knew pretty well where I was at.

Day 7. (a) 15; (b) 14; (c) 14; (d) 12; (e) 18. *Av., 14.6.*

(b) V. I'm a little bit puzzled toward the end. The first part is the way my hand goes. It seems like I have to think more about it when I'm puzzled.

Day 8. (a) 17; (b) 14; (c) 12; (d) 11; (e) 8. *Av., 12.4.*

(e) V. You know the door I've been missing? [S has been going 5-5b-6.] I've just discovered, if I keep my pencil up to the side, I'd go right on through. Q. What did you think about in the maze? A. Don't remember anything, except at that door.—Apparently the process is now automatic, except at one or two difficult points.

Day 9. (a) 10; (b) 9; (c) 8; (d) 6; (e) 6. *Av., 7.8.*

(a) Q. How do you remember it? A. I guess by going over it so often. Q. That's *why* you remember it. *How* do you do it? A. I don't know. Q. What do you think about while you go through? A. I don't think about anything, sir [answer positive].

(e) Q. Do you think much about the maze? A. Well, I know I'm drawing it. Q. Do you think which way to go as you go through it? A. No, sir; no, sir. [Shakes head emphatically.]

Day 10. (a) 9; (b) 7; (c) 6; (d) 8; (e) 7. *Av., 7.4.*

S answers questions in the same way and as positively as on preceding day. He draws maze with open eyes on a separate sheet, making three errors. Seemingly the process is now almost entirely automatic or at least unclearly kinesthetic.

(e) Q. Did you ever think this maze was like the last one? A. No, sir; it is nothing like the last one. [Positive.]

Subject C appears to be guided throughout maze M by visual imagery, although on the tenth day he finds that visual sensory elements added to the imaginal ones tend only to confuse him. The visual imagery, however, seems to remain important. With

maze N the kinesthetic factor appears as early as the second day and is very important on the third day and thereafter. The performance has become largely automatic by the eighth day and almost completely so on the ninth day. Visual imagery seems to play very little part in the performance with maze N. It is probably present early and in difficult parts later, just as the kinesthetic elements appear at difficult points after the rest of the performance has become automatic.

Subject D.

Maze M. Day 1. (a) v 55; (b) v 35; (c) v 12; (d) 18; (e) i 543.

Day 2. (a) v 9; (b) v 19; (c) v 20 (d) v 10; (e) i 685.

S is mute and has to be urged constantly to keep at the task.

Day 3. (a) v 14; (b) v 7; (c) 13; (d) i 448; (e) i 555.

Day 4. (a) v 8; (b) v 10; (c) v 8; (d) i 440; (e) i 60.

Day 5. (a) v 12; (b) v 6; (c) i 76; (d) i 42; (e) i 32.

Day 6. (a) v 13; (b) i 25; (c) i 57; (d) i 24; (e) i 37.

S is still mute, although he sometimes answers questions by nods. He co-operates otherwise fairly well.

Day 7. (a) v 7; (b) i 25; (c) i 46; (d) i 19; (e) i 22.

(e) Q. How do you remember how to go? (This question has often been asked before, but S has never answered it.) A. Feel it, I think. I kind of remember which way I went before. Q. Do you keep thinking about the way the maze looks? A. Well, yes; I do in a kind of indefinite way. But I think principally about the feel.

Day 8. (a) v 7; (b) i 17; (c) i 14; (d) i 18; (e) i 14.

Day 9. (a) i 16; (b) i 15; (c) i 17; (d) i 12; (e) i 12.

(e) Q. How do you remember how to go? A. I feel the way I've been before. Seems to come naturally to me. That's about all. Q. Do you keep seeing what the maze looks like or is it all just feeling? A. It's all just feeling; I feel with my pencil.

Day 10. (a) i 23; (b) i 56; (c) i 16; (d) i 14; (e) i 14.

Day 11. (a) i 21; (b) i 15; (c) i 15; (d) i 20; (e) i 20.

S has been mute the last two days.

Day 12. (a) i 20; (b) i 13; (c) i 10; (d) i 9; (e) i 13.

(e) Q. How did you remember how to get around? A. It just came natural to me. I've been around so much. Q. Did you have to think about it all the time. A. Yes [positive]. Q. Did you think about the way it looked or the way it felt to do it?

A. It was mostly by the feel.—S is asked to draw the course on a separate sheet, but hesitates very much and finally gives up after placing a few right angles on the sheet. It would seem that the 'feel' is more important than visual imagery.

Maze N. Day 1. (a) 244; (b) 133; (c) 176; (d) 56; (e) 43. *Av., 146.4.*

(d) Q. Did you remember how to get out? A. Kind of; yes. I had a kind of indefinite feeling, just the same as on the other maze.

Day 2. (a) 107; (b) 33; (c) 24; (d) 299; (e) 51. *Av., 102.8.*

(b) Q. How did you know how to get out? A. By the sound of the pencil. Q. How did that help you? A. I don't know. There was a kind of indefinite rhythm about it. It played a tune.

Day 3. (a) 69; (b) 23; (c) 24; (d) 36; (e) 40. *Av., 38.4.*

(c) V. That was the best I ever done, because I put my mind on it. Q. What did you find when you put your mind on it? A. Found it easier to get out. Q. Did you know where you were in the maze? A. I just felt with my mind. Q. Can you tell me how that was? A. I kind of anticipated where I was going to go through the next door.

Day 4. (a) 182; (b) 32; (c) 60; (d) 51; (e) 29. *Av., 70.8.*

Makes error first time of going into 5b and then back to O, and continues it in all trials. S is almost mute today.

Day 5. (a) 81; (b) 21; (c) 22; (d) 15; (e) 16. *Av., 31.0.*

(b) Q. What was the difference between this time and last time? A. Lots! I didn't know what I was doing this time; last time I did.—A sudden lapse into automatism?

(d) Q. How was it that time? A. I got into the game that time. It's like football when you've got the ball. You want to get through and you just get through.—The *Aufgabe* is conscious, the performance less so, perhaps automatic.

Day 6. (a) 31; (b) 24; (c) 18; (d) 12; (e) 18. *Av., 21.0.*

(d) Q. Can you tell me how you got out that time? S thinks a while. A. No, I can't. Q. Did you think how the maze looked? A. No, I didn't. Q. Did you think about it at all? A. Yes, I tried to get out as hard as I could. Q. Anything else? A. No, I don't remember any.

Day 7. (a) 34; (b) 17; (c) 12; (d) 13; (e) 16. *Av., 18.4.*

(e) Q. How was it today? A. I just thought about going. I went in that direction mostly [motions to left]. Q. Did you imagine the way the maze looked? A. No, I didn't.

Day 8. (a) 11; (b) 11; (c) 22; (d) 17; (e) 13. *Av., 14.8.*

(e) Q. Did you get through by the feel or by thinking how the maze must look? A. By the feel. Q. Entirely, or do you think of the looks of the maze a little? A. Entirely. Q. Are you sure? A. Yes, I'm sure.

Day 9. (a) 19; (b) 16; (c) 8; (d) 16; (e) 14. *Av., 14.6.*

Day 10. (a) 14; (b) 8; (c) 11; (d) 14; (e) 10. *Av., 11.4.*

(e) Q. How did you remember the maze these times when you went so fast? A. Why I didn't think about anything, except about getting out. Q. When you thought about getting out, did you think about the end of the maze or did you think of getting by each place?—S thinks for a long time. A. I didn't think about the end of the maze or about each place either; I just thought about getting out. I thought I must hurry.—Apparently only the *Aufgabe* remains conscious.

Day 11. (a) 16; (b) 13; (c) 8; (d) 17; (e) 10. *Av., 12.8.*

Day 12. (a) 12; (b) 13; (c) 12; (d) 15; (e) 14. *Av., 13.2.*

(e) Q. How did you remember it? A. I didn't remember anything. Q. How did you get through then? A. Oh, I remembet it some by the feel. That maze, there's a give to it,—a kind of give where the openings are. I remember the way it gives, the way it feels when you push against the openings.—S's description corresponds well to the clear kinesthetic experience that the writer gets, when with one motion the pencil can be made to shoot through three or four doors. S is asked to draw maze and draws a continuous course, that resembles the actual one but little, except at the last (6-7-8-x).

On account of the muteness of D, the introspections for maze M are incomplete. He seems, however, to have followed a kinesthetic cue. With maze N, the kinesthetic factor is important from the start. Visual imagery is not reported at all. There is evidence of the performance becoming automatic about the fifth day, but there is also evidence that the kinesthetic factor had not entirely vanished at the end of the series. The *Aufgabe* to get out quickly apears to have remained conscious throughout.

Subject E

Maze M. Day 1. (a) v 18; (b) v 12; (c) v 10; (d) v 8; (e) i 23.

(e) Q. Did you know where you were? A. I knew a good deal of the time, at the start and the end.

Day 2. (a) v 8; (b) v (6); (c) v 6; (d) v 6; (e) i 53.
Day 3. (a) v 7; (b) v 6; (c) v 5; (d) i 280; (e) i 163.
(e) V. I try to go back to the center to get the trail. I feel as if I could get out if I started right.
Day 4. (a) v 6; (b) v 5; (c) v 4; (d) i 677; (e) i 21.
(d) S at first cannot get beyond 3-4a, and then beyond 5-6-7a.
Day 5. (a) v 5; (b) v 5; (c) i 47; (d) i 167; (e) i 33.
Day 6. (a) v 5; (b) v 5; (c) i 51; (d) i 47; (e) i 15.
(c) Q. How do you know how to get through? A. I have an idea how the maze is formed. I think a good deal of the way it looks; I think where the doors ought to be and feel for them.
Day 7. (a) v 4; (b) i 16; (c) i 17; (d) i 9; (e) i 10.
Day 8. (a) v 5; (b) i 10; (c) i 10; (d) i 12; (e) i 8.
(e) Q. Tell me all you can about how you remembered it. A. I remembered about how many times I had to go round. To keep off the wrong alleys you have to judge about how far to go. As soon as I felt I was moving my hand too far, I felt I was wrong and went back. As much as I could I tried to picture the way it looked when I'd seen it. Q. Did you see it pretty clearly? A. Yes.
Day 9. (a) i 9; (b) i 8; (c) i 11; (d) i 8; (e) i 8.
(e) Q. How do you remember it? A. A good deal from seeing it. You have to get the movements formed in your mind before you start out. Then you go around and feel part of the way. Q. How much do you do by feel and how much by the way it looks? A. About one-half by memory,—forming it in your mind the way it is,—one-quarter by feeling, and one-quarter by the looks of it when you last saw it. Q. What do you mean by "forming it in your mind the way it is"? A. The way it looked to go right. That's different from the other; the memory of the looks of the maze has the wrong ways to go in it, too.
Day 10. (a) i 10; (b) i 7; (c) i 16; (d) i 17; (e) i 5.
(e) Q. How was that? A. Did a lot by feeling, more than by memory. Q. Did you think about each gate? A. No; I thought it would pay to rub the sides and feel the way, as well as to have in my mind [=visual imagery of the right course; see above] about where the gates are.
Day 11. (a) i 7; (b) i 8; (c) i 6; (d) i 6; (e) i 5.
Day 12. (a) i 6; (b) i 7; (c) i 7; (d) i 5; (e) i 5.
(e) Q. How do you remember to get through? A. Memory [= visual imagery] about two-thirds; then also by feeling and the way it looked last time I saw it. [*Cf.* day 9.] Q. What do you mean by memory? A. Memory of the door you go through,—

according to looks.—S now draws maze on separate sheet perfectly, accompanying it with verbal comment, *e.g.*, "First you go up, then you go down," etc. Evidently the memory is largely visual, but little kinesthetic.

Maze N. Day 1. (a) 780; (b) 140; (c) 45; (d) 40; (e) 17. *Av., 204.4.*

(e) Q. How did you do that? A. I did it a little bit by memory, like last time. I could tell by actions, too, how it felt, just where I was. By knowing where the door is I get the lay of the land. If it were all turned around [indicates turn through 90°] I couldn't do it as easy. But by its always being one way, I get the feel of the actions, just where each gate is.

Day 2. (a) 22; (b) 16; (c) 14; (d) 14; (e) 12. *Av., 14.6.*

Before beginning S presents a drawing of the right course which he has made at his leisure in the ward. It has one error, in that it omits 6 in 5-6-7.

(a) S fails to find 5-6 at once, the error in his drawing. V. One place there kind of slipped my memory.

(b) V. I did that by memory and by feeling. Q. When do you use feeling? A. I use feeling when I think I'm a little lost from my memory.—S seems to try to replace the kinesthetic cues of last time by visual, as far as possible.

Day 3. (a) 10; (b) 9; (c) 7; (d) 7; (e) 7. *Av., 8.0.*

Day 4. (a) 7; (b) 8; (c) 7; (d) 6; (e) 7. *Av., 7.0.*

(a) Q. How did you remember it? A. At the start I paused to think which way I ought to go. Q. Did you picture it in your mind? A. Yes; if I do that I don't get lost so easy. When I started I happened to think, "Which way do I make the first turn?" Thought right away it was towards me.—S describes course throughout.

(e) V. As soon as I've gone through a door I can tell by the feel pretty much how to go.—Apparently S has some motor cues, although he reports visual in most cases.

Day 5. (a) 7; (b) 7; (c) 7; (d) 7; (e) 6. *Av., 6.8.*

(b) Q. How are you doing it? A. I imagine a picture of the maze. I see the way all the time. When I get on a street I know just which way to go and find my way out.—The behavior of S bears this statement out. He pauses slightly before each door and feels for it. He does not make the long sweeps through several doors, that seem to come with the motor habit.

(e) V. Here's the thing that bothers me [indicates, by drawing on the table, 5-6-7-8]. I don't seem to touch anything. I hit the door too easy.—In a purely motor habit 5-6-7-8 is made by a

single sweep of the arm. That the ease with which this may occur disconcerts S, is an indication that the performance is not motor.

Day 6. (a) 6; (b) 5; (c) 5; (d) 5; (e) 4. *Av., 5.0.*

(c) Q. Do you definitely think of how to go at each turn? A. Yes. I see the drawing of the maze. Q. Does the feel of the maze help you? A. About one-fifth. I don't feel as much for the openings as at first, because I've got so now I know pretty well where they are. Q. How do you know where they are? A. By the plan. I see in my mind where they are.—S has almost completely substituted visual imagery for kinesthesis.

(d) V. I went so fast that my mind could hardly keep up with my hand. It bothered me. I'm going to try to do it next time by feeling more and not to have to think as fast as I go.

(e) V. I done that part by feeling. I went too 'cautionate' by thinking and knowing where I was. By feeling you don't go so 'cautionate' but the sides keep you where you ought to be at.—Thus S consciously adopts a kinesthetic guide and saves a second.

Day 7. (a) 6; (b) 9; (c) 6; (d) 5; (e) 4. *Av., 6.0.*

(b) S makes error in 5b. Q. What was the matter? A. I let my hand go too much and got in the wrong place.

(e) Q. How did you do it that time? A. A good deal by memory of how it looked and partly by the way it felt.—Visual imagery again.

Day 8. (a) 7; (b) 5; (c) 5; (d) 4; (e) 4. *Av., 5.0.*

(b) Q. How was that? A. I was thinking about it. I didn't like to trust to the way it felt.—So S discards the kinesthetic guide and returns to the visual as more trustworthy.

(e) S is asked to draw maze and does so perfectly and with confidence. Q. Did you think this maze was anything like the last one? A. I thought it was somewhat similar. I don't think it's like it.

Subject E is evidently strongly visual. Maze M is learned entirely in visual terms, and does not become automatic. Maze N, lacking visual perceptual cues, is remembered in the first five trials somewhat kinesthetically. The subject then, however, draws out the course for himself on paper, and thereafter visual imagery plays the important rôle, to the partial exclusion of kinesthesis. Later (sixth day) the subject consciously discards the visual for the kinesthetic performance, because he finds it difficult to keep the visual imagery clear while going rapidly; but

he discovers that kinesthesis is not immediately reliable and returns (probably seventh day) to the visual method.

Subject F

Maze M. Day 1. (a) v 28; (b) v 12; (c) v 8; (d) v 7; (e) i 159.

Day 2. (a) v 8; (b) v 8; (c) v 5; (d) v 5; (e) i 48.

Day 3. (a) v 6; (b) v 6; (c) v 5; (d) i 37; (e) i 179.

Day 4. (a) v 5; (b) v 4; (c) v 5; (d) i 73; (e) i 27.

(e) Q. How do you remember it? A. I know where the openings are.—S is asked to draw maze, but does not succeed at all. Perhaps his performance is not visual. If motor, it is far from the perfection that is apt to occur before the maze habit becomes motor, for S makes many errors.

Day 5. (a) v 4; (b) v 5; (c) i 15; (d) i 13; (e) i 13.

S is questioned repeatedly about his manner of performance, but is unable to give significant answers.

Day 6. (a) v 4; (b) v 4; (c) i 19; (d) i 12; (e) i 14.

Day 7. (a) v 4; (b) i 14; (c) i 12; (d) i 9; (e) i 14.

(d) Q. How do you know how to go? A. I know the way it goes. I tell by the feel. [Marks out imaginary course with finger in the air.]

Day 8. (a) v 4; (b) i 14; (c) i 7; (d) i 12; (e) i 6.

(e) Q. How do you know how to go? A. I go by the feeling. It goes right around. I can tell ahead of me where I'm going. Once in a while I get lost.

Day 9. (a) i 9; (b) i 19; (c) i 7; (d) i 7; (e) i 6.

(e) Q. How do you remember how to go? A. Just by going around. Q. What are you thinking of while you're going around? A. I can tell if there's anything in front of me or behind me. There's a feeling comes over me. I can tell when harm is coming before it get's inside of four feet, front or back. Q. Where is the feeling? A. It strikes me here about [indicates chest and sides]. I get the same feeling when I'm running the maze. Q. Is the feeling the only thing that tells you how to go? A. That's the only thing. Nothing else.—S declares that he always has this feeling for anything that he cannot see.

Day 10. (a) i 7; (b) i 5; (c) i 10; (d) i 15; (e) i 16.

(a) S is told before trial to observe what he thinks about while running the maze. After trial: V. That time I just felt my way. Q. Did you know how you were going? A. No; just kind of kept going till I found my way out [motions rhythmically with pencil in air].

(e) In last three trials S has been confused in making 4-5. Heretofore he has always made 3-4-5 in one sweep. This time he overcomes the difficulty in making 4-5 by returning to 3 again and making 3-4-5 in one movement as before, remarking at the time, "I have to go back and get a new start". He always makes 6-7-8 and sometimes 5-6-7-8 in one sweep of the arm. The getting of the new start indicates that the consciousness may be a sort of a rhythmical consciousness, and even that it may involve the organic factors usual to a rhythmical consciousness (see day 9).

Day 11. (a) i 10; (b) i 6; (c) i 5; (d) i 4; (e) i 11.

Day 12. (a) i 7; (b) i 9; (c) i 5; (d) i 4; (e) i 3.

(b) Q. How did you do it? A. I was feeling my way out.—Longer time in this trial and preceding is due to the fact that in attempting 5-6-7-8 he stops short of necessary distance for getting into 8, and comes back into 7b. Each time he corrects himself by returning to 5 and making 5-6-7-8 in one sweep. Evidently this is a single unit in a motor chain.

(e) Makes one full error and several false starts even at this speed. Is unable to draw maze at all correctly.

Maze N. Day 1. (a) 372; (b) 162; (c) 85; (d) 27; (e) 35. *Av., 136.2.*

Day 2. (e) 34; (b) 42; (c) 63; (d) 15; (e) 14. *Av., 33.6.*

(a) Q. How do you remember the thing? A. By the way it goes. Q. Do you mean the looks? A. No, by the way it goes. Q. What do you mean by that? A. I remember just how it goes [motions with arm and shoulder in air].

Day 3. (a) 17; (b) 8; (c) 12; (d) 11; (e) 20. *Av., 13.6.*

(a) Q. How do you do it? A. Just keep looking for openings so I can get out. If I can't find an opening I go right on.—This statement well describes the actual behavior of S. He moves rapidly all the time, frequently breaking pencil points. When confused he may move rapidly back and forth over not more than an inch of path, and he continues violently bumping around until he gets out.

Day 4. (a) 9; (b) 6; (c) 19; (d) 13; (e) 9. *Av., 11.2.*

(b) Q. Do you know how to go? A. No, I just get in and keep going around. The faster I go the quicker I get out, so long as I don't hesitate. As soon as I go to hesitation, it takes me a long while to get out.—S has in some instances jumped the walls in his haste. On being put back he is always confused and it takes him some time to get again what is apparently his motor adjustment.

Day 5. (a) 9; (b) 5; (c) 11; (d) 14; (e) 7. *Av., 9.2.*

(b) V. I have to go fast to get through. If I go slow I get all mixed up. I have to hurry and then I make mistakes.

In general S makes 0-1-2, 3-4-5, and 5-6-7-8, each as a single movement. His troubles are of two kinds: either he wanders back and forth in a bewildered manner before he can connect two of these units, or his adjustment falls short so that he misses the last door in one and finds himself almost hopelessly lost.

Day 6. (a) 7; (b) 5; (c) 8; (d) 7; (e) 7. *Av., 6.8.*

(d) V. I don't think much about it. I just keep going right through.

Day 7. (a) 10; (b) 6; (c) 8; (d) 4; (e) 11. *Av., 7.8.*

Day 8. (a) 9; (b) 10; (c) 6; (d) 7; (e) 6. *Av., 7.6.*

(a) Q. How did you do it that time? A. When I first start there are two or three little places where I can't go; then just as soon as I can get out of them I can go the full length. Q. After you get out of them do you have to think about your going? A. No, I go right along. It just takes one whole draw [moves arm about in an easy sweep].

Day 9. (a) 7; (b) 7; (c) 6; (d) 6; (e) 5. *Av., 6.2.*

S still makes many errors, as many as six in a single trial, but moves so rapidly that he gets out in short time in spite of them. He is unable to draw the maze satisfactorily on a separate sheet.

Subject F appears to be as strongly motor as E was visual. He reports no visual imagery at any time, but learns both mazes principally in motor terms. Although he makes very short times, the performance remains far from perfect. Apparently he knows the maze in three or four units, each of which he can shoot through rapidly if that particular performance is touched off properly. His course in both mazes resembled a violent bumping around with occasional spurts through several passages, as he got the right cue for that particular unit. It is possible that for this subject these units group themselves into a sort of rhythmical consciousness, which may be organically carried. It is not possible to say whether the performance ever became automatic or remained purely kinesthetic.

Subject G

Maze M. Day 1. (a) v 28; (b) v 14; (c) v 10; (d) v 10; (e) i 129.

Day 2. (a) v 10; (b) v 8; (c) v 6; (d) v 6; (e) i 142.

Day 3. (a) v 7; (b) v 6; (c) v 6; (d) i 72; (e) i 78.
Day 4. (a) v 7; (b) v 6; (c) v 5; (d) i 148; (e) i 29.
(d) V. I can tell when I'm on the right track from being familiar with the course. Q. How can you tell? A. I see the way in my mind.
Day 5. (a) v 6; (b) v 5; (c) i 37; (d) i 26; (e) i 22.
Day 6. (a) v 5; (b) v 4; (c) i 33; (e) i 25; (e) i 33.
(c) V. I know I have to follow a little circle, then go to here [motions in air], then two breaks and through. It's just like a fireplace [closes hand and diagrams in air]. You have to get out of the fireplace and then around the mantel.—Evidently this is visual imagery.
Day 7. (a) v 6; (b) i 23; (c) i 17; (d) i 21; (e) i 30.
Day 8. (a) v 5; (b) i 15; (c) i 34; (d) i 37; (e) i 37.
(e) Q. How do you remember it? A. I know I have to go this way. [Traces course with closed eyes on table.] There's a notch, here's a door, then there's a street, etc.—Evidently S is still using visual imagery.
Day 9. (a) i 23; (b) i 20; (c) i 17; (d) i 23; (e) i 15.
(e) Q. How do you remember how to go? A. I remember the formation. It's like an oriental design,—a grill-work.—S is asked to draw maze with eyes shut on separate paper. He does so with only one important error, although the lines cross each other very often. He draws slowly, pausing as if to think, suggesting reliance upon visual imagery.
Day 10. (a) i 23; (b) i 15; (c) i 18; (d) i 16; (e) i 14.
(a) V. I know the formation now. We call that casaban effect on a lace curtain. [S has been dry-goods salesman.]
Day 11. (a) i 84; (b) i 22; (c) i 22; (d) i 22; (e) i 21.
(e) Q. How do you do it? A. I do it by remembering the formation, the way it looks. I can draw a sketch of it.—S is asked to draw the course, eyes open. His drawing is correct for all the turns, although poorly proportioned.
Maze N. Day 1. (a) 214; (b) 129; (c) 71; (d) 66; (e) 286. *Av., 15.2.*
Day 2. (a) 152; (b) 62; (c) 135; (d) 93; (e) 457. *Av., 179.8.*
(e) Goes back and forth in 2, 3, and 4, but does not attempt 4-5 for a long while. When S does make 4-5, he gets right on through.
Day 3. (a) 41; (b) 40; (c) 31; (d) 35; (e) 23. *Av., 34.0.*
(a) Q. Do you or do you not think of the way the maze looks? A. Oh, I see it somehow. I try to get the thing in my eye. That's the way I learn things.

(c) V. When I get out from the starting point, I know just where I am. Q. Is it by the way you remember the maze that you know where you are? A. Yes, and by the sense of touch. Over at the right I get in a little pocket and feel my way out by the sense of touch. And when I'm coming down the long passage [probably 8] I feel I'm going to get out.

(e) Q. How much of that was touch and how much eye? A. Greater portion eye. I went through by touch and the eye and the brain traveled with the pencil. I know when I'm wrong, as I see it with my eye, as it were.—Evidently still visual imagery with some kinesthesis is S's method.

Day 4. (a) 32; (b) 25; (c) 19; (d) 35; (e) 19. *Av., 26.0.*

(e) V. It brings two senses together, the sense of feel and the sense of thought. The thought comes when I am wrong. There are a number of places on which I'm uncertain. Then the thought comes in. The sense of feel is when I'm all right. I know how to strike in against the walls.—This statement, volunteered entirely without suggestion from the experimenter, may be taken to mean that kinesthesis has already entered in to a large extent and that visual imagery is important only in difficult places.

Day 5. (a) 18; (b) 22; (c) 19; (d) 16; (e) 14. *Av., 17.8.*

(e) V. I knew it when I started out. I had my mind on the diagram. But I went by the door. I made too much haste. [Error at 4-5.]

Day 6. (a) 15; (b) 22; (c) 13; (d) 16; (e) 15. *Av., 16.2.*

(a) V. It goes all right for a while; then when I get here [indicates 5-6-7-8 by drawing on the table] it's sort of a mystery how I get through. It's sort of a double ditch. I jump through like a spring. When I get through I know I'm all right, but it's a mystery how I get there.—The course 5-6-7-8 is the part which is made so easily in one sweep of the arm and which bothered subject E, who was proceeding with visual imagery. The experimenter also found the ease and rapidity with which the three doors could be passed very surprising indeed.

Day 7. (a) 10; (b) 14; (c) 11; (d) 11; (e) 17. *Av., 12.6.*

(e) Q. How do you think of it? A. I see where all the little notches are—just as I think of anything you know. It's just as if I had a thing committed to memory.

Day 8. (a) 15; (b) 19; (c) 19; (d) 12; (e) 10. *Av., 15.0.*

Day 9. (a) 16; (b) 11; (c) 11; (d) 9; (e) 8. *Av., 11.0.*

Day 10. (a) 16; (b) 10; (c) 9; (d) 9; (e) 24. *Av., 13.6.*

(e) Q. How did you do it? A. Give me that pad and I'll show

you.—S is given pad and draws route correctly in about 5 seconds. Q. Does that mean that you see the thing in your mind that way when you do the maze? A. Yes, I see it all the time.

Q. Is this maze anything like the first? A. It's similar, only reversed.

Subject G, like E, is strongly visual and negotiates the difficulties of both mazes throughout in visual terms. In maze N, however, there are also at least some kinesthetic factors, mentioned especially on the third day, which probably continue throughout, secondary to the visual factors, which alone are reported later. Possibly the kinesthetic part becomes automatic at the end. The larger part of the complex, however, remains conscious as visual imagery.

Subject H

Maze M. Day 1. (a) v 18; (b) v 20; (c) v 16; (d) v 10; (e) i 326.

Day 2. (a) v 15; (b) v 8; (c) v 8; (d) v 7; (e) i 83.

Day 3. (a) v 9; (b) v 8; (c) v 6; (d) i 62; (e) i 32.

Day 4. (a) v 9; (b) v 7; (c) v 5; (d) i 15; (e) i 13.

(d) V. I didn't think about the maze. I was counting while I was doing it. I felt as if my hand were just driving along.

(e) Q. How was it this time? A. Just struggling my way. Just struggling all along. I thought of nothing else. I got out myself this time.—S explains that last time he thought that some one else got out for him while he was thinking of something else. This is quite in keeping with S's delusions.

Day 5. (a) v 5; (b) v 6; (c) i 16; (d) i 12; (e) i 14.

Day 6. (a) v 6; (b) v 6; (c) i 12; (d) i 9; (e) i 15.

Day 7. (a) v 5; (b) i 14; (c) i 14; (d) i 25; (e) i 12.

(e) V. Just feel along. I know the pencil is bound to reach from one groove to another; I hold the pencil on the side of the maze from which I know it runs out. Hardest thing is to decide if I run out whether I am in right direction—whether I'm going out or back to the center. Q. How do you know which side the opening is on? A. I try to get out to the longer line and then I know I'm right. When I can't get out on one side I try the other. —Certainly this report does not indicate that the performance is surely motor, in spite of the short time; its exact character is uncertain, whether visual, verbal, attitudinal or motor.

Day 8. (a) v 6; (b) i 11; (c) i 14; (d) i 8; (e) i 7.

Day 9. (a) i 9; (b) i 11; (c) i 11; (d) i 17; (e) i 7.
Day 10. (a) i 13; (b) i 10; (c) i 12; (d) i 12; (e) i 26.

(e) Q. How do you remember how to go? A. I don't remember how to go. I go with the pencil. I follow the pencil and when it goes out I go with it. I just go along through the maze.—The performance is kinesthetic, perhaps automatic.

Day 11. (a) i 7; (b) i 7; (c) i 5; (d) i 9; (e) i 12.
Day 12. (a) i 4; (b) i 8; (c) i 6; (d) i 4; (e) i 7.

(d) Q How do you feel when you go through the maze? A. Oh, I feel my hand just go through. It goes lightly. Most of the time I hardly realize I'm going through the maze.—S fails to draw the course at all correctly. Evidently kinesthesis and automatism account for his final performance.

Maze N. Day 1. (a) 218; (b) 31; (c) 68; (d) 24; (e) 22. *Av., 76.2.*

Day 2. (a) 17; (b) 22; (c) 17; (d) 15; (e) 15. *Av., 17.2.*

(a) Q. How did you get out then? A. I don't know. I don't know where the openings are. I just feel with the pencil.

(e) 4 errors. Q. How did you do that? A. I don't know. I have to work my mind to get out. I work my way out. I don't know where the passages are.

Day 3. (a) 13; (b) 10; (c) 9; (d) 8; (e) 10. *Av., 10.0.*

(a) Q. How did you remember it? A. I don't remember it. I haven't seen it. I just imagine how it is and then go with the pencil. Q. Do you imagine how the maze must look or how you ought to move your pencil? A. I just imagine how it looks.

(d) Q. Do you see the maze all the time in imagination while you are going through? A. Yes. Q. Is that what makes it possible for you to go through? A. I don't think about it most of the time. I just see it before me. If I were to think about how I'm going, I would have to go very slowly. It just seems as if I went along unconsciously and got out. I have to go too fast to pay attention.—The performance is then almost automatic already. The visual imagery, though present, is not the guide by which the subject proceeds. Perhaps it carries the *Aufgabe.*

Day 4. (a) 14; (b) 11; (c) 6; (d) 8; (e) 6. *Av., 9.0.*

(c) Q. Did you think every time you went one way just how to go? A. No. I see the whole maze in imagination all the time. But if you show it to me I think I would get mixed up and have to go slow. I depend on the chance of speed to get me through.

After day 4, S complains about the work and refuses to continue with it.

Subject H reports only kinesthetic processes and automatic performances definitely. Both mazes were run in short times by kinesthetic guides before many trials, and probably the performance became automatic later. There is indication of processes other than motor at the start, but the subject is not explicit.

As far as it is possible to express such results schematically, we have attempted to summarize the temporal courses of learning for the different subjects in Table XVI. The principal initial, middle, and final conscious concomitants of the learning performance are given in three columns, "v" and "k" standing for visual imagery and kinesthetic processes respectively, and "a" for movement without consciousness, that is to say, automatic movement. It must be remembered that the table shows only what was definitely reported. Many processes may have been present that were not elicited by questioning. The table moreover aims to show only those processes which stood for (*i.e.*, meant) the means of guidance within the passages. Other processes relevant to the maze are not considered.

It will be observed that generally in the course of consciousness during the learning of the maze there is first visual imagery which gives place to kinesthesis, which in turn gradually becomes less and less clear until complete automatism is reached.[1] Four subjects began thus with visual imagery; in one (G) the processes became partly kinesthetic; in one (B), completely kinesthetic; in one (A), completely kinesthetic and then partially lapsed; and one (C), completely kinesthetic and then completely lapsed, that is to say, the movement became automatic. In four subjects the processes were kinesthetic from the start. In one of these (F) they remained kinesthetic; in one (D), they partially lapsed; in one (H), they lapsed completely; while in one (E) they became visual.

[1] This is the typical course of human maze learning found by Day and the writer, *loc cit*, and again by the writer, *op. cit.*

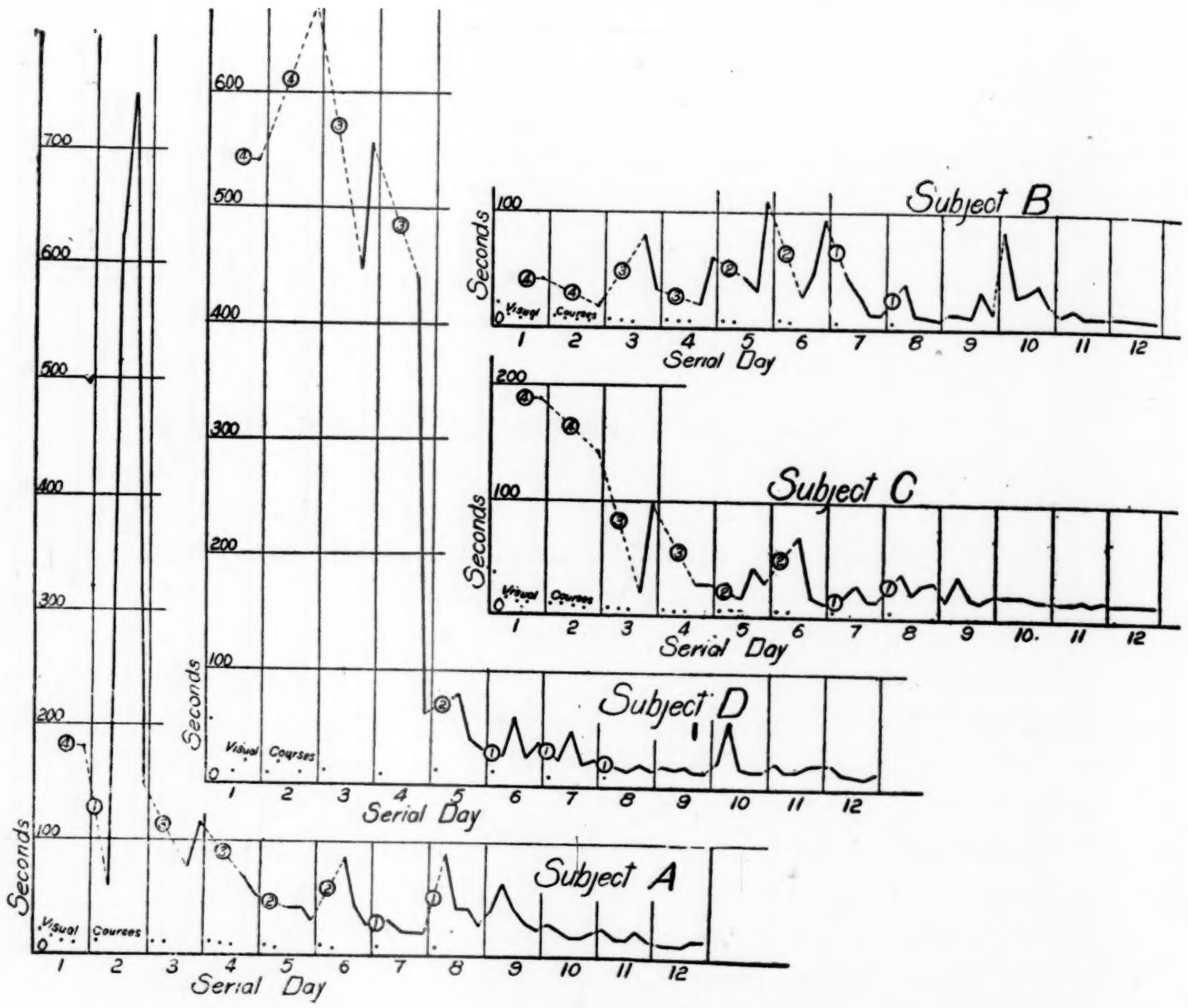
TABLE XVI

CONSCIOUS PROCESSES

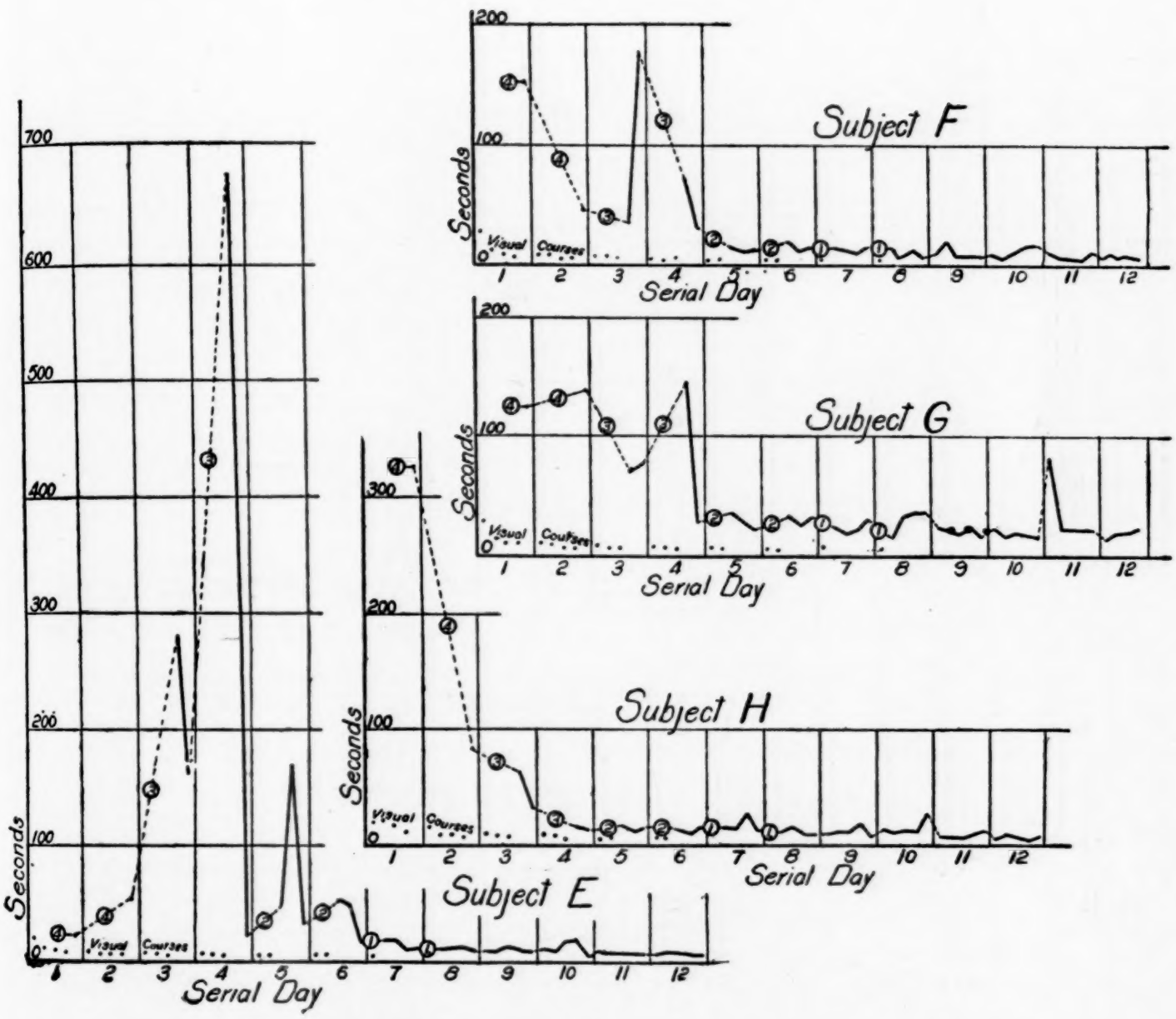
Representing the means of guidance in the learning of maze N. v = visual imagery; k = kinesthetic sensations or imagery; a = automatism (no conscious processes).

	Conscious processes concomitant with:		
Subject	Initial Performance	Middle Performance	Final Performance
A	v	k	k + a
B	v	k	k
C	v	k	a
D	k	k + a	k + a
E	k	v + k	v
F	k	k	k
G	v	v + k	v + k
H	k	a	

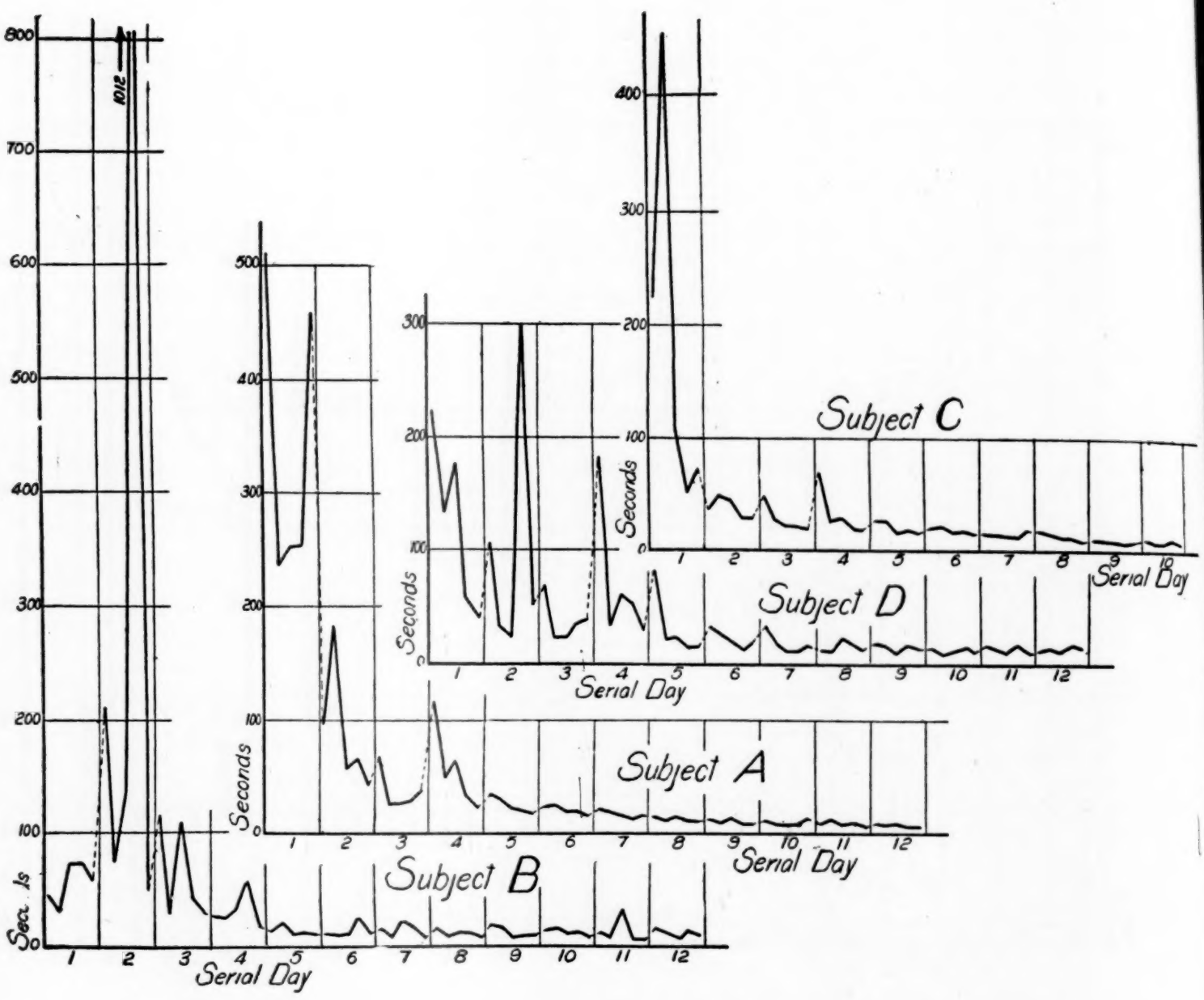
In order that the numerical relations may be better seen, the average times for maze N are tabulated in Table XVII. The subjects are ranked there upon their average times from day 2 to day 8 inclusive, day 1 being omitted because the times are determined largely by chance and their inclusion would do some subjects, who learn well, an injustice. The results are also shown quantitatively in curves. Figs. 18-25 show learning with maze M. The curve drawn in each case is for only those courses made with the maze obscured. The dotted lines indicate breaks between days, and the small numbers in circles upon the dotted lines, the number of trials made in the interval with the maze in sight. The actual values of the times of these visual courses are shown below the curves as unconnected dots. Figs. 26-33 are for maze N. Here there were no visual courses. The dotted lines indicate breaks between days.



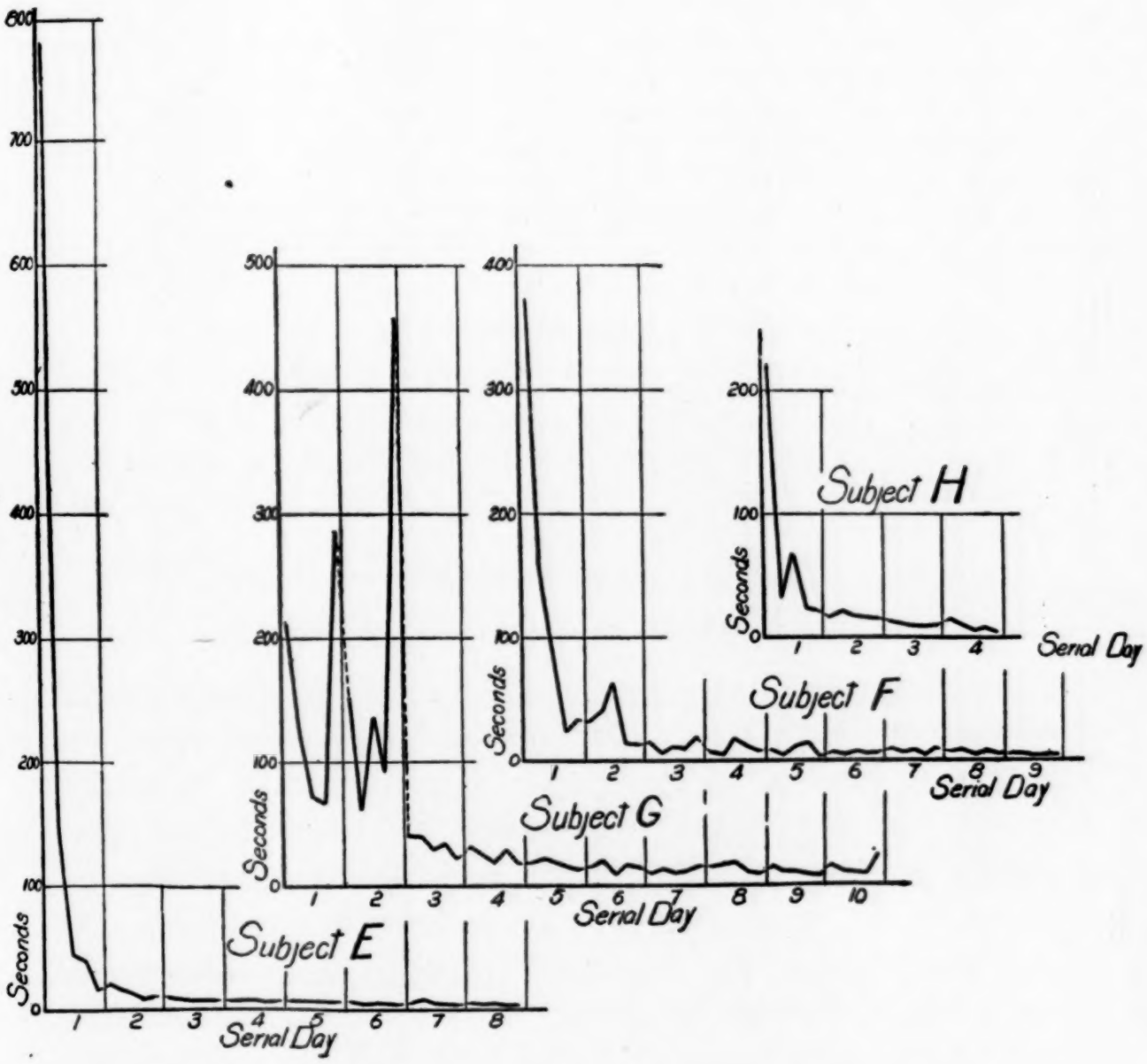
Figs. 18-21. Learning with Maze M, Series I. Subjects A, B, C, and D. Solid line is for times with maze obscured from view. Dotted lines, for breaks between sessions. Small numbers in circles, for number of intervening trials with maze visible. Dots below, for actual times of visual trials.



Figs. 22-25. Learning with Maze M, Series I. Subjects E, F, G, and H. Solid line is for times with maze obscured from view. Dotted lines, for breaks between sessions. Small numbers in circles, for number of intervening trials with maze visible. Dots below, for actual times of visual trials.



Figs. 26-29. Learning with Maze N, Series II. Subjects A, B, C, and D. Maze obscured from view throughout. Dotted lines indicate breaks between sessions.



Figs. 30-33. Learning with Maze N, Series II. Subjects E, F, G, and H. Maze obscured from view throughout. Dotted lines indicate breaks between sessions.

TABLE XVII

MAZE N—MAZE OBSCURED FROM VIEW

Figures show average times in seconds for five trials on serial days 48 hours apart. Rank of subject is based on days 2 to 8 inclusive (except for H).

Serial Day	Subject A	B	C	D	E	F	G	H
1	341.8	56.4	182.0	146.4	204.4	136.2	153.2	72.6
2	88.8	297.2	37.6	102.8	14.6	33.6	179.8	17.2
3	36.8	65.2	32.4	38.4	8.0	13.6	34.0	10.0
4	56.6	32.8	32.0	70.8	7.0	11.2	26.0	9.0
5	23.6	14.4	21.2	31.0	6.8	9.2	17.8	
6	20.4	14.2	18.4	21.0	5.0	6.8	16.2	
7	16.6	13.8	14.6	18.4	6.0	7.8	12.6	
8	12.2	11.2	12.4	14.8	5.0	7.6	15.0	
9	10.4	12.8	7.8	14.6		6.2	11.0	
10	10.2	11.8	7.4	11.4			13.6	
11	8.6	13.8		12.8				
12	7.8	10.0		13.2				
Rank of Subject	7	6	4	8	1	3	5	2

IV. RUG-MAKING

Procedure and Method of Quantification

We shall now proceed to examine the performances of these subjects in the learning of a practical mechanical operation such as is involved in the simpler forms of skilled industrial work. For this purpose the making of hooked rugs was selected as being not difficult to learn and as providing an operation, the product of which was readily quantifiable. It was hoped, in fact, that there might prove to be no difference in the quality of the rugs, so that the only variable to be considered would be the speed of making. This hope, however, was not fully substantiated, although the differences in quality, with one exception, were not great.

The hooked rugs are made in the following manner. A piece of ordinary burlap or sacking is stretched and tacked upon a rectangular wooden frame, and forms thus the base for the rug. The rug is worked into this with woolen strips cut from old army uniforms. The only tool required is a hook, made of 3/16-inch steel rod, bent at one end into a loop that serves for a handle. The other end is filed down to a taper, about 3/32 of an inch at the end, and is then filed well in at one side, so that a small knob remains projecting at the end on one side of the tapered point. The whole hook is

about five inches long. The rags to be used in the rugs are cut or torn into strips about half an inch wide. A strip is held in the left hand underneath the frame, the hook is thrust through the burlap, the strip is laid smoothly over it upon the hooked side, and the hook is pulled through the burlap toward the handle almost horizontally, thus pulling through a loop of the cloth. The loop is pulled well through, straightened out, if crooked, and pulled back by the left hand down over the hook stem, which is turned with the hook side away from the strip. The loop is, of course, not pulled back through the burlap, but against the hook above the burlap, thus being adjusted smoothly at a uniform height. The hook is removed from the loop thus made and thrust through the burlap a few threads further on, where another loop is pulled through, close against the first. Thus the process continues. When a new strip of cloth is begun or the one in use finished, the end is pulled through the burlap and cut off the same height as the loops.

The experimental rugs were made 32 by 18 inches. It was planned to make them perfectly plain without any pattern at all, in order that they might be equally difficult throughout. After commencing work, however, it was discovered that the work was so monotonous that the subjects before long grew tired of

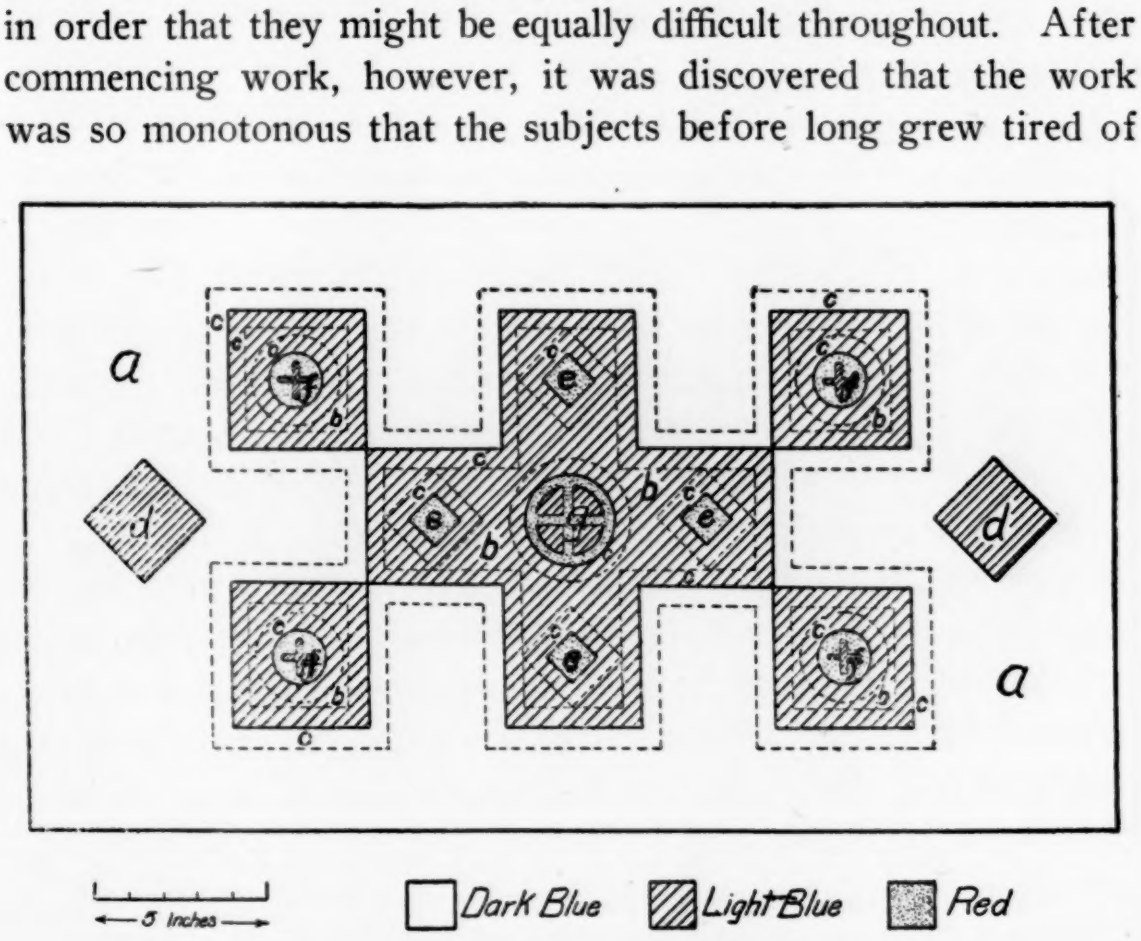


Fig. 34. Rug Pattern. Letters indicate relative difficulty of parts, "a" being the easiest, "g", the hardest. See text and Table XVIII.

it, and it soon became a question whether they could be kept at it long enough to finish the rugs. Accordingly a pattern was

introduced in order to stimulate interest, and later the pattern was complicated somewhat for the same purpose. The pattern, which was not designed for artistic effect, included large squares, a figure intended not materially to complicate the problem. The details of the center were added still later. The design is shown in Fig. 34. Blue army coats were used for the base, light blue army capes and trousers, and in one a gray cape, for the center, and red flannel for the small figures.

In general all subjects followed the same order in making the different parts of the rug. First the plain outside field (a, Fig. 34) was filled in as far as the diamonds (d). Then these diamonds were worked and the outside filled in all around the rug to within one or two inches of the large central form. Then in order that there might be a clear-cut line between the outer and the central parts, the central portion was outlined in dark blue (c). The outside was then filled in to the outline mark. Next the central portion was again outlined, this time on the inside, by light blue (c), thus assuring the clear-cut line of demarcation between the two colors. Next the diamonds and circles were outlined in light blue (c), and then the rest of the center was filled (b). After this the small diamonds were filled in in red (e), then the small circles, in red with a blue cross in center (f), and finally the large central circle with a red cross and blue filling (g) was worked.

It may be objected that the pattern finally adopted was by no means even nearly equally difficult throughout. This is true, but it is not thought that the matter is nearly as serious as at first appears. After they had completed the rugs, the subjects were questioned as to their opinion of the relative difficulty of the different parts of the rug. Four of the five who completed rugs agreed exactly in ranking the different parts in difficulty; the fifth did not differ by more than one grade from the others for any one part. The letters designating the parts in Fig. 34 are arranged so that they indicate the difficulty of the part according to the estimate of the subjects, "a" being the easiest, "g", the hardest. The reasons for the differences are readily

understood. The filling in of the outside part (a) is plain, regular work and is naturally comparatively easy. The filling in of the center (b) is slightly more difficult, because by the time the center is reached the rug has been largely filled in and the burlap is consequently stretched tighter, so that it is more difficult to pull the loops through. There are also more small corners to be worked in the center. The outlining of parts (c) is again more difficult because care must be taken to keep one edge of the row worked even. The large diamonds (d) are difficult because they have to be kept straight and uniform; the small diamonds (e) are more so, because in addition the burlap is tighter in the center and because the red flannel proved harder to loop. The small circles (f) are still less easy, because they contain a small cross; and the large circle (g) is most difficult of all because of the additional detail that it involves. If, however, we examine Table XVIII, in which the approximate areas of each part of the rug are given we find that the difficult portions make up only a very small proportion of the entire rug. Parts "a", "b", and "c" are all regular work and differ only slightly from one another in difficulty. They make up, however, 94.6% of the entire rug. Part "a" alone forms 60.5% of the rug. The difficult details, "d", "e", "f", and "g", constitute only 5.4%. Obviously then, if we wish to study learning, we have only to neglect the last six hundredths of the operation, in order to have the whole process nearly equally difficult.

TABLE XVIII

RUG AREAS

Approximate areas of the different parts of the rug arranged in order of difficulty. Letters are those used in text and in figure 34.

Letter	Part of Rug	Area Sq. in.	Area %	
a	Filling in outside	351	60.5	
b	Filling in center	24	4.2	94.6%
c	Outlining center	172	29.9	
d	Large diamonds	13	2.6	
e	Small diamonds	4	.7	
f	Small circles	7	1.2	5.4%
g	Large circle	5	.9	

The series were begun with the subjects working alone with the experimenter for fifty minutes every other day,—all the time

available by the experimenter. It soon appeared, however, that, in order to finish the rugs within a reasonable time as well as to keep up the interest of the subjects, it would be necessary to work much longer and oftener. Accordingly it was decided to allow all the subjects to work together in a large room. The periods were increased to 150 minutes and the subjects worked every afternoon except Sunday. This change was made on the fifth day for all subjects except A and H, for whom it was made on the second day.

It is thought that for most of the subjects the working together acted very little as a distraction. The refusal of subject G to work shortly after the change may have been partly due to the fact that he was ashamed to be seen employed in industrial work, but there must have been other reasons, as he also refused to continue the cancellation test. The other patients, except H, came after a while to converse more or less freely and to seem not averse to the social feature that was thus introduced into the work.

During the first part of the work the experimenter worked regularly at a rug, while the patients worked. This was done for three reasons. In the first place, it was necessary for the experimenter to understand the operation thoroughly, in order to assist and instruct the subjects. In the second place, it seemed advisable, in order to secure the continued co-operation of the subjects. who, it must be remembered, are generally averse to performing manual work of this character, and who, in this case, had little incentive to work, to take rug-making off the plane of manual labor for the benefit of the hospital, and to mark it as an operation which, for "scientific purposes", it was desirable for even the experimenter to do. In the third place, it was thus made possible to use the record of the rug made by the experimenter as a control. The experimenter, as a rug-maker, is referred to as "X". Working always whenever the subjects worked, his series is somewhat different from the others. At first he works 100 and 150 minutes on alternate days, his results, however, being computed for each fifty-minute period. On the ninth day and thereafter he worked the 150-minute periods every afternoon.

The record for each subject shows the number of loops made each day and the part of the rug worked, the latter being recorded on an outline map of the rug. In counting loops each free end at the beginning or end of a strip was counted as a full loop, since approximately as much effort was required to pull the end through as to pull a loop. The subjects cut and tore their own strips. No account was taken of the time consumed in this operation, as it was small. It was assumed that it was about equal for all subjects.

Results

The results are shown in Table XIX. Here are given the number of loops per minute made in each working period the value being placed opposite the total amount of time spent on the rug up to the end of the period considered. The length of the period, for which each figure given is the average rate, is the difference between the total time given for that period and the total time for the last entry made. Work done in 50-minute periods is, however, marked by an "x", that done in 100-minute periods by "xx". All other work was in 150-minute periods, except in some cases that done on the final day. The table also shows the part of the rug worked upon in the particular period, the part being referred to by letter (Fig. 34 and Table XVIII). Its rather broken form is due to the attempt to combine three different serial orders for purposes of comparison.

The data of Table XIX are much more readily comprehended by reference to the curves of Figs. 35-42. Here the letters at each point indicate the part of the rug worked upon. As before, "x" signifies that the work was done in a 50-minute period, "xx" in a 100-minute period, while uncrossed dots indicate 150-minute periods. The curves must be interpreted only in connection with the letters. In general, the rate tends to fall off at the end of the series, but this is because the more difficult parts of the rug are recorded there. If a drop in the curve is accompanied by the introduction of a letter indicating that a more difficult part was begun, it does not indicate that there was not actual improvement. Take, for example, the curve of subject

TABLE XIX

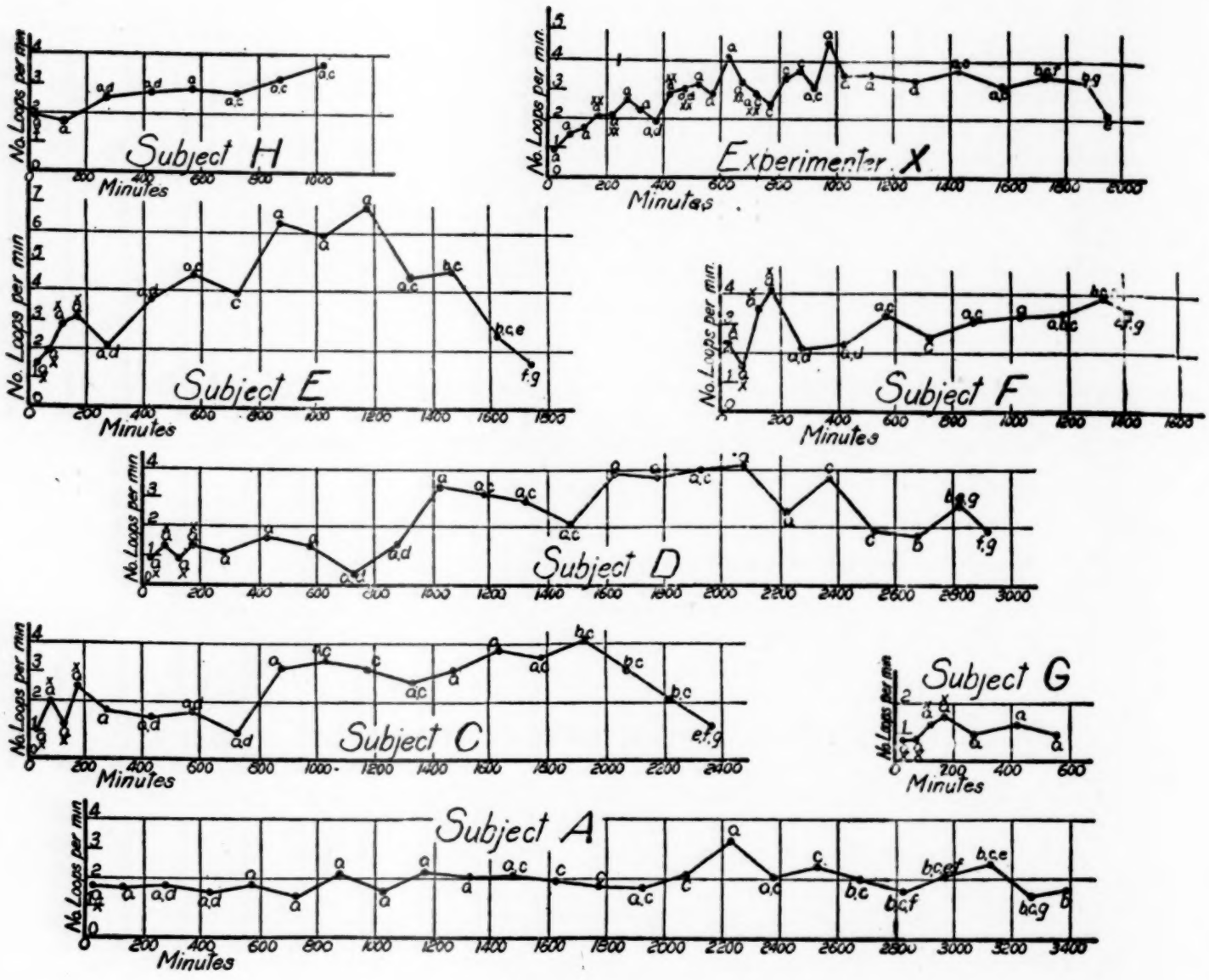
RUG-MAKING

Figures show rate of working, in number loops per min., in relation to total time of working in min. Letters refer to parts of rug worked upon; see Fig. 34 and Table XVIII. x = 50-minute working period; xx = 100-minute period. All other periods are 150 minutes, except on final day for each subject.

	Subjects															
	A		C		D		E		F		G		H		X	
Total no. min.	Rate	Pt.	Rate	Pt.	Rate	Pt.	Rate	Pt.	Rate	Pt.	Rate	Pt.	Rate	Pt.	Rate	Pt.
50	1.72x	a	.96x	a	.84x	a	1.52x	a	2.26x	a	.66x	a	1.96x	a	.98	a
100			1.86x	a	1.34x	a	1.98x	a	1.58x	a	.74x	a			1.42	a
150			1.20x	a	.84x	a	2.84x	a	3.52x	a	1.34x	a			1.64	a
200	1.69	a	2.42x	a	1.30x	a	3.08x	a	4.04x	a	1.54x	a	1.75	a	2.04xx	a
250															2.10xx	a
300															2.62	a
350	1.70	ad	1.71	a	1.07	a	2.09	ad	2.18	ad	.97	a	2.58	ad	2.34	a
400															1.92	ad
450															2.84xx	a
500	1.45	ad	1.43	ad	1.61	a	3.75	ad	2.27	ad	1.29	a	2.89	ad	3.08xx	ad
550															3.20	a
600															2.92	a
605											.86	a				
650	1.75	a	1.52	ad	1.35	a	4.44	ac	3.29	ac			2.92	a	4.20	a
700															3.34xx	a
750															2.84xx	ac
800	1.39	a	.94	ad	.37	ad	3.92	c	2.59	c			2.77	ac	2.48	c
850															3.40	c
900															3.68	c
950	2.06	a	3.10	a	1.39	ad	6.30	a	3.13	ac			3.22	ac	3.12	ac

1000													4.56	a
1050													3.50	a
1100	1.59	a	3.39	ac	3.33	a	5.94	a	3.26	a				
1150												3.62	ac	
1200													3.59	a
1250	2.19	a	3.11	c	3.04	ac	6.90	a	3.29	abc				
1350													3.31	a
1400	2.02	a	2.61	ac	2.86	ac	4.43	ac	3.82	bce				
1450									3.68	efg				
1500													3.66	ac
1550	2.05	ac	3.02	a	2.05	ac	4.63	bc						
1650													3.13	ac
1700	1.85	c	3.89	a	3.89	a	2.54	bce						
1800													3.49	bcf
1805							1.57	fg						
1850	1.76	c	3.69	ac	3.61	a								
1950													3.25	bg
1980													2.20	e
2000	1.62	ac	4.02	bc	3.97	ac								
2150	2.13	c	3.10	bc	4.02	a								
2300	3.28	a	2.13	bc	2.47	a								
2450	2.02	ac	1.19	efg	3.62	c								
2600	2.40	c			1.83	c								
2750	1.99	bc			1.66	b								
2900	1.55	bcf			2.75	beg								
2950					1.88	fg								
3050	2.06	bcef												
3200	2.46	bce												
3350	1.40	bcg												
3440	1.57	b												

Tot. area, sq. in.....	576	576	576	576	576	70	278	576
Tot. no. loops.....	6591	6173	7061	6384	4329	644	3057	6039
Tot. time, hrs. and min..	57 : 20	40 : 50	49 : 10	30 : 05	24 : 10	10 : 05	19 : 10	33 : 00
Av. no. loops per min...	1.91	2.52	2.39	3.53	2.99	1.06	2.68	3.05
Av. no. loops per sq. in..	11.4	10.7	12.3	11.1	7.5	9.2	11.0	10.4



Figs. 35-42. Learning in Rug-making. Seven subjects, and X as control. Letters indicate relative difficulty of parts, "a" the easiest, "g", the hardest. See Table XVIII, Fig. 34, and text. × = work done in 50-minute period. ×× = work done in 100-minute period. All other work, except on final day, done in 150-minute periods.

E, which shows learning, although it ends about on a level with the start. Throughout the first four days there is steady improvement. On the fifth day "d" is introduced and the rate falls off, but recovers the next day in spite of "d". The following session some "c" does not prevent improvement, but on the next day the subject works at "c" all the time and goes more slowly. Practice in "d" is different and is thus probably not beneficial for working "c". When "c" is dropped and only "a" is worked, again there

is a sudden rise, this time to the peak of the curve, the dent in the top of which is due to some unexplained cause. When "c" is reintroduced, however, there is again a drop, which goes still farther with the introduction of "e", "f", and "g". When interpreted in this manner the curves of subjects E, F, H, and X, all show learning. C does also, except for the next to the last two days. G did not continue long enough to develop marked improvement. D, the most erratic of the subjects in all the tests, shows sudden improvement after 750 minutes, which continues almost to the end. This improvement appears to be independent of the relative difficulty of parts. It is probably due to the fact that the low points on the curve are caused not so much by any intrinsic difficulty in the problem, as by lapses of attention in the subject. Subject A alone shows no increase in rate, but it cannot be said that he does not improve, since he is able to maintain the same rate in the more difficult parts as in the easier portions of the rug.

It has been remarked that the rugs did not all prove to be alike in quality of workmanship. The rug of F, for example, was much poorer than the rest (unless the end of a rug made by G be expected), because he insisted on working rapidly and carelessly making very large loops. Although he finished in about 80% of the time of his nearest competitor, he put in only about 70% as many loops. Upon casual inspection the other rugs were, however, not markedly different. Accordingly it was decided to grade them in quality by having them judged by a number of normal people. Ten men and five women, most of them attendants and nurses in the hospital, were asked to arrange the rugs in a series according to the quality of workmanship, neatness, regularity, and apparent carefulness of construction. The partly worked rugs of G and H were also placed in the series as exactly as possible, by comparison with the corresponding parts of the other rugs. The vote resulted in a remarkable uniformity of opinion. The average ranks of the eight rugs with the mean variations are given in Table XX. The mean variations are small; in only two cases are they greater than a single unit of

rank. Four of the rugs were placed in exactly the same position by more than half of the observers.

TABLE XX

QUALITY OF RUGS

Figures are average ranks and mean variations, based upon the opinions of 15 normal persons, each of whom ranked the rugs independently.

Subject	A	C	D	E	F	G	H	X
Av. rank	5.3	2.9	4.6	1.4	7.1	7.7	4.4	2.6
M. V.	±.89	±1.08	±1.06	± .56	± .34	± .46	± .68	± .66

It had seemed possible that the number of loops made per square inch might be a measure of the quality, not that mere closeness of stitches would make for excellence, but that it might be an index of general carefulness. This relation, however, does not seem to hold although there may be some slight interdependence. The correlation between quality, as determined by the vote, and closeness of loops is 30.9%. (Pearson: method of rank-differences.) It is interesting also to note that the closeness of the loops appears to be almost entirely independent of the speed of working, the correlation being—14.1%,—the negative sign indicating perhaps a slight tendency to place the loops farther apart when working fast.

In Table XXI we compare the ranks of the subjects in rapidity and in quality of work. It will be observed that the two vary similarly. It seems that the workers who work rapidly, work also well. The correlation between the two factors is 73.8%. F has already been noted as a marked exception to this rule, a fact which has been borne out by other rugs that he has since made. Some of these later rugs were made so rapidly as to be hardly fit for use; while others in which he was constantly admonished to go slowly were quite creditable. If F be excluded in computing the correlation between speed and accuracy, the value is 90.6%.

It is interesting to note that the rug of the experimenter (X) ranks, not first, but second both in quality and speed. One subject surpassed and several nearly equaled the experimenter, indicating that the operation could be learned by some of the dementia precox patients almost as readily as by a normal subject. The experimenter, it may be added, while perhaps not naturally adept

in operations requiring manual dexterity, has had some manual training in other lines of work.

TABLE XXI

COMPARATIVE RANKS OF SUBJECTS IN QUALITY AND SPEED IN RUG-MAKING

Basis of ranking	Subjects							
	A	C	D	E	F	G	H	X
Quality	6	3	5	1	7	8	4	2
Speed	7	5	6	1	3	8	4	2

Correlation = 73.8%

Character of the Operation

In order that the exact character, on the conscious side, of the operation of rug-making might be thoroughly understood and compared with the processes of learning already described, introspections on the operation were obtained from the subjects after they had completed about twenty hours of work, that is to say, at the time when the regular filling in had been learned as well as possible and before the more difficult parts were begun. These introspective reports, it must be remembered, were made at the time that the subjects were beginning to give their most satisfactory reports on the maze and the subjects apparently comprehended the meaning of the questions in a way that would never have been possible without considerable preliminary training. With regard to the rug-making, the subjects were first asked to describe their method of procedure and were then questioned in order to determine as far as possible what parts of the operation were carried consciously and the sorts of perceptual cues and imagery that were present.

The manner of questioning the subjects and the kind of answers elicited have already been fully shown under the introspections for the maze. We shall content ourselves here with giving rather fully an account based upon the introspections of the experimenter, made during the rug-making period. This will be supplemented by a brief statement of the report of each subject.

Experimenter (*X*). The position of each loop in the burlap is determined by a visual perceptual cue. The hook is thrust through and the hole thus made enlarged either automatically or with unclear kinesthesis. The arrange-

ment of the cloth strip on the hook beneath the burlap is accompanied by unclear kinesthetic sensations and a clear visual image of the strip, the latter carrying the meaning that the strip is being brought toward or away from the experimenter, as the case may be. [Since the dierction of working the strip was frequently altered and the arrangment upon the hook is dependent upon the direction, it is not surprising that the processes having this meaning should remain clear.] The bringing of the hook through the burlap is sometimes automatic, sometimes accompanied by unclear muscular sensations in the hand and arm. These sensations occasionally become clear when difficulty is encountered in getting the loop through. There is also a more or less clear visual perception of the loop and of the end of the hook, which persists until the loop is adjusted. The pulling down of the loop over the hook is almost invariably automatic.

Subject A. S makes a definite judgment, apparently in visual terms, of the position of the loop, and then sticks the hook through, arranges the cloth upon it, and pulls it up automatically,—at least S insists that he never thinks about these movements. The arrangement of the loop after it is pulled through involves visual, kinesthetic, and probably other processes.

Subject C. The determination of the position of the loop appears to be largely visual, the arrangement of the strip beneath the burlap and the pulling of the loop through, automatic. The loop is adjusted with at least an unclear visual accompaniment, which becomes clear whenever there is difficulty in arranging it properly.

Subject D. The position of each loop is located by visual perceptual cues. The hole is made and enlarged and the strip arranged on the hook with clear kinesthetic sensations determining the adjustment. S is uncertain about the rest of the operation.

Subject E. A definite visual perception precedes the determination of the place where the hook shall be thrust through. The thrust is automatic, but the placing of the strip upon the hook is always accompanied by kinesthetic sensations in the fingers and nearly always by a visual image of the cloth. Unclear kinesthesis and probably an unclear visual perception accompanies the pulling through of the loop, the visual perception becoming clear whenever difficulty that calls for a slight change of adjustment is met. The adjustment of the loop is carried in clear kinesthetic and visual processes. The pulling of it taut by the left hand, however, is entirely automatic.

Subject F. The position of each loop is determined by a visual perception. It is impossible to say what the later processes may be, as S, showing a different attitude than that taken toward the maze and cancellation forms, takes great pride in the care with which he works, so that he will not admit that any operations at all are done without the most careful attention. He cannot, however, describe 'what his thinking is like' in these cases.

Subject H. The report of this subject is also not clear. The position of the loop is determined in visual terms. Probably a large part of the rest of the operation is conscious, although the type of processes cannot be told with certainty.

The subjects are apparently all very much alike. The simpler

movements are early guided by kinesthesis and later become automatic. The more complicated movements or those movements that have to be varied from time to time according to chance conditions—the various adjustments of the cloth—are accompanied by a mixed perception of which the sensory part may be kinesthetic or, if the operation is in sight, visual, and the imaginal part (if the interpretation of the reports is correct) almost entirely visual. When conditions interfere with the performance of an automatic movement, the altered movement is clearly conscious. The rug-making experience on the conscious side thus combines, in a rather complex way, elements involved in the learning of both the cancellation forms and the mazes.

COMPARISON OF RESULTS

From time to time we have ranked subjects in the various tests performed. As a matter of final interest we have brought together in Table XXII the ranks of the subjects in all the tests.

TABLE XXII

RANKS OF SUBJECTS IN DIFFERENT TESTS

	Subjects							
Tests	A	B	C	D	E	F	G	H
Attention	1	4.5	2.5	8	6	4.5	2.5	7
Immediate memory	5	5	5	8	5	1.5	5	1.5
Apperception	2	7	5	8	6	4	3	1
Directions	1	3.5	7	8	5	3.5	6	2
Tapping (speed)	4	7	4	8	1	6	4	2
Aiming (accuracy)	6	2	7	3	1	8	4	5
Kinesthetic memory	7.5	5	7.5	3.5	1	2	6	3.5
Cancellation (speed)	3	8	7	6	1	5	4	2
Cancellation (accuracy)	4	8	1	6	5	7	3	2
Maze (speed)	7	6	4	8	1	3	5	2
Rug-making (speed)	6		4	5	1	2	7	3
Rug-making (accuracy)	5		2	4	1	6	7	3

The table does not show quite as much variation between the tests as might be expected. E, for example, does well in most of the tests, while D is almost always very poor. This fact is shown numerically by the average correlation of the sixty-six possible combinations in pairs of the twelve tests. This correlation is

+21.9%. It does not, however, necessarily mean that one observer has a tendency to excel in all the factors of all tests, another to do poorly. The fact that the majority of tests are of a motor character suggests that the uniformity may be the result of excellence in a common factor.

It proves, however, not to be possible to prophesy the ability of a subject in one test on the basis of his ability in another test. We find many apparent inconsistencies. For example, accuracy in cancellation and accuracy in rug-making are both highly correlated with the speed of making dots in the tapping test, but they are not highly correlated with one another. Such high correlations, if significant at all, cannot indicate excellence merely in some single factor, but must be the result of a complex interplay of at least several factors. In such a case, correlation of two factors with a third might occur without there being a correlation between the two factors themselves. This view is supported if we consider the speed tests alone. Speed of tapping, of cancellation, and of running the maze are all highly correlated with each other. Speed of making rugs shows a high correlation with the maze speed, but does not show high correlation with the speed of tapping or of cancellation. Possibly it is significant that the apparent inconsistency occurs with the more complicated operation, that of rug-making.

The correlations greater than fifty per cent. for the last five items of Table XXII are as follows:

Time of cancellation:—tapping, 82%; directions, 65%; immediate memory, 58%; apperception, 55%; maze, 55%.

Accuracy of cancellation:— tapping, 62%; apperception, 57%.

Time of maze:—rug speed, 82%; tapping, 76%; immediate memory, 71%; kinesthetic memory, 55%; time of cancellation, 55%; rug accuracy, 51%.

Rug speed:—time of maze, 82%; kinestheic memory, 79%; rug accuracy, 59%; immediate memory, 51%.

Rug accuracy:—rug speed, 59%; tapping, 57%; time of maze, 50%.

It will be seen that the cancellation test, the maze test, the tapping test, and the rug-making are all rather closely related,

if the similar ranking of the subjects can be taken to indicate this fact, but that it is not possible to determine exactly what that relation is or to factor the processes ino terms of each other with the data that we have at hand.

EFFECT OF OCCUPATION UPON THE SUBJECT

Therapeutic value has often been claimed for the employment of the insane. It is not possible, however, in the present case to determine the exact effect of the work upon the patients. In the first place, the time was too short and the number of patients too few to justify a generalization. In the second place, the extra-experimental conditions were not controlled. A change in the general condition of the patient during the period of experimentation might have been caused by some change in the hospital routine affecting him outside of the experimental hours. In the third place, it is not possible to separate the effect of employment from the effect of sympathetic association with the experimenter, who was able to form a much closer, personal relation with the patients than was possible for the nurses and attendants.

In some of the subjects there were definite alterations of disposition as the work progressed. In spite of the difficulty in interpreting these changes, it is thought worth while to record them.

Subject A was at first dull and apathetic in the experimental work and obstinate in the ward, having to be tube-fed. Later he became much interested in the rug-making and would sometimes talk about it, while in the ward he was most tractable. He had, however, been subject to such changes in disposition before, and it is possible that the period of good behavior was helped on by his removal during the period of experimentation to a ward that he liked especially well.

Subject B showed little change. He was not employed in rug-making.

Subject C became more cheerful and less bothered by worries as the experimental period progressed. His manner also became less apathetic. He was, however, allowed a limited parole at

about the time the change appeared, and this may have helped his improvement.

Subject D became much interested in the rug-making and frequently expressed his pleasure in it. He was no longer mute or apathetic, as he had been early in the experimental period. His manner while in the ward remained unchanged, however.

Subject E at first complained very much of being imprisoned, asked constantly for parole, and talked all the time about his troubles and his hallucinations. He became later very much interested in all the work, no longer complained, and stated that his hallucinations had become very infrequent.

Subject F was always cheerful. He conceived a great fondness for rug-making, and made many more rugs after he had completed the experimental one. There was, however, little change in his condition, except that his characteristic inane laugh became very infrequent.

Subject G remained about the same throughout the period, except for two excited spells. The first was manifested only in the ward, and did not affect his experimental work. The second was connected entirely with the experimental work, and resulted in his refusal to continue with the rug-making and the cancellation test.

Subject H remained consistently complaining throughout, and worried constantly over trivial matters. Among other things he complained of the experimental work, and finally refused to do it altogether.

It appears, then, that Subjects B, F, G, and H showed no improvement in condition during the experimental period; that A and C showed decided improvement, which may, however, have been contributed to by outside causes, and that D and E showed decided improvement without there having been any obvious change in outside conditions, although the improvement in D was manifest only during the hours of experimentation. The most striking case was that of E, who, it will be recalled, excelled in almost all of the tests except those given at the very beginning of the experimental work.

CONCLUSIONS

1. Dementia precox patients, can be readily trained in the performance of simple tests of learning or of more complex operations of an industrial nature.

2. These patients are available as subjects for psychological investigation, provided the apparatus used is not too complicated. They can be trained without great difficulty to give introspective reports of the more prominent features of conscious experience.

3. The patients show large individual differences in ability to learn the operations, in manner of procedure, and in the consciousness accompanying the performance.

4. The patients are capable of fairly precise motor adjustments. The accuracy of a very simple motor adjustment does not increase with practice, but does depend upon the extent and the speed of movement. In the latter case accuracy decreases more rapidly than speed increases.

5. There is but little evidence for transfer of practice from an operation that is but slightly motor in character.

6. The course of consciousness in learning a maze is that of the normal subject. Verbal, visual, and attitudinal factors are usually replaced by kinesthetic, which turn lapse as the movement becomes automatic.

7. There is indication that employment may be beneficial to some patients, although this cannot be asserted positively.

8. The patients are capable, in simple industrial operations, of a quality of work, sufficiently good to be commercially valuable.